THE APPLICATION OF SCIENCE TO CROP-PRODUCTION

An Experiment carried out at the Institute of Plant Industry, Indore

by

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and

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SECOND IMPERIAL ECONOMIC BOTANIST (ON DEPUTATION TO THE INSTITUTE OF PLANT INDUSTRY, INDORE)

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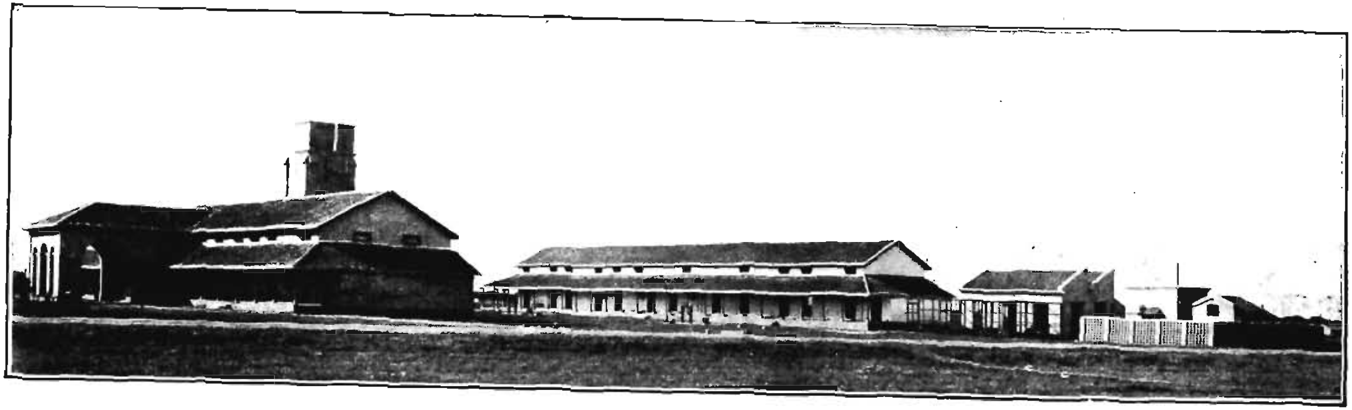
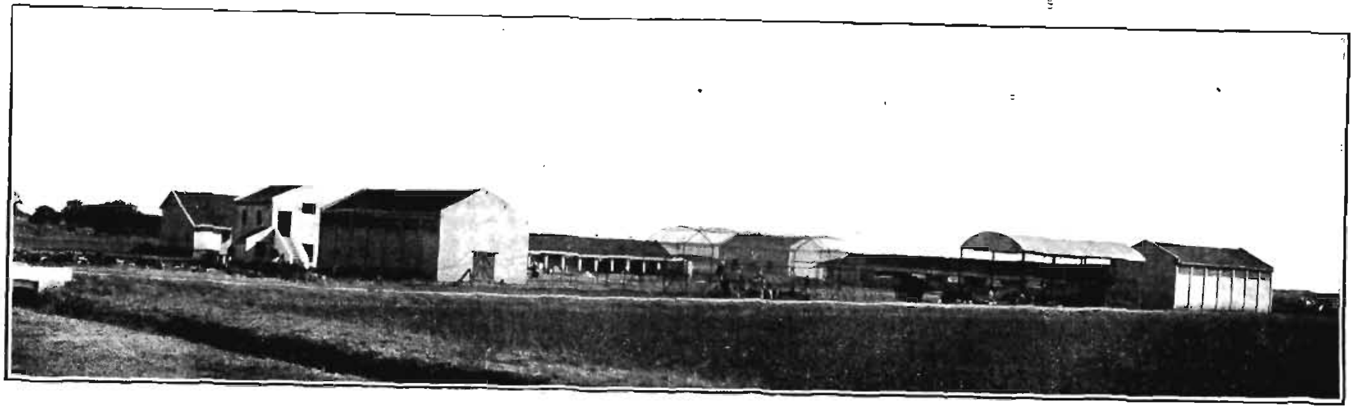


Laboratories



Farm-buildings

GENERAL VIEW OF LABORATORIES AND FARM-BUILDINGS

CHAPTER I

THE GENESIS OF THE INDORE EXPERIMENT

The Institute of Plant Industry at Indore arose as a natural development of the work of the Botanical Section of the Agricultural Research Institute at Pusa. For twenty years—1905 to 1924—the writers were engaged in exploring the directions in which botanical science could profitably be applied to the crops of India. During this period many lines of approach, both in the field and in the laboratory, were studied. The general nature and scope of these investigations will be apparent from the list of papers published since 1905 (see page 62). During the progress of the work, it became increasingly evident that the organization of an agricultural research institute, on the basis of practical agriculture on the one hand and on the separate sciences on the other, was by no means the ideal arrangement. It was soon discovered that the problems, presented in the improvement of a crop, cannot be split up into a number of parts without grave detriment to the whole. To attempt to do so not only leads to the fragmentation of the problem but also seriously limits that freedom, which is so essential to the scientific investigator of economic questions. The centre of the subject of crop-production must always be the plant itself, which obviously can only be effectively studied in relation to the soil in which it grows, to the conditions of village agriculture under which it is cultivated and with reference to the economic uses of the product. In exploring the problems of crop-production on these lines from 1905 to 1924 the obsolete character of the present organization of agricultural research in India became apparent. The need for the broadening of the subject, as well as for the development of new methods and new lines of attack, became more and more insistent. The only practical solution of the difficulty appeared to lie in making crop-production one of the main sections of agricultural research work in India, and in abandoning the present fragmentation of the subject altogether. As it is not easy to change any form of organization from within, this involved the foundation of a new Institute for crops, at which the development of the plant could be studied as a biological whole and not piecemeal.

In 1919, an opportunity arose of founding a separate institution for the study of crops on the lines indicated above. In that year the late

Mr. Bernard Coventry, C.I.E., who was due to retire from the post of Agricultural Adviser to States in Central India, proposed that we should succeed him. Mr. Coventry's duties consisted in advising a group of States in Central India on agricultural development, and in supervising the demonstration farms and the district work in the various States. The weak point of the scheme was the absence of an experiment station, under the direct control of the Agricultural Adviser, at which results could be obtained, where the agricultural officers of the States could be trained and where they could see for themselves what great possibilities for development exist. We suggested that the scheme should be expanded and that it should include a research institute for crops at Indore, of the type outlined above, and under the direct control of the Agricultural Adviser. This was agreed to by the late Mr. Coventry and by the Agent to the Governor-General in Central India (the Hon'ble Sir Oswald Bosanquet, K.C.S.I.). As the States could not provide all the money required for the capital and recurring expenditure, the Government of India was asked to assist the scheme. The Viceroy (Lord Chelmsford) supported the project, and the Government of India agreed to furnish the capital cost of the buildings and equipment and to provide a sum of Rs. 50,000 a year for the recurring expenditure. Soon after this decision was reached, a period of acute financial stringency set in which compelled the Government of India to withdraw from the scheme. For a time the project remained in abeyance. In 1924, the newly established Indian Central Cotton Committee adopted the Indore scheme and agreed to furnish the capital cost of the buildings and equipment, together with a large portion of the annual expenditure. Eight of the original Contributing States—Indore, Datia, Dhar, Dewas (Senior Branch), Jaora, Ratlam, Sitamau and Narsinghgarh—agreed to come into the revised scheme. The Indore Darbar again placed at the disposal of the Institute, for 99 years, an area of 300 acres of land at a nominal rental of Rs. 300 per annum. A grant of two lakhs of rupees towards the capital cost of the Institute as well as an annual contribution of one lakh of rupees was then voted by the Central Cotton Committee. The amended scheme was sanctioned in 1924, and work was commenced on October 24th of that year. It was decided that the affairs of the new Institute should be managed by a Board of Governors, consisting of six members, with the Agent to the Governor-General in Central India as President. The Indian Central Cotton Committee are represented by three members; the Holkar State by one member. The remaining Contributing States appoint two representatives in rotation

who serve for one year. The Director of the Institute is the Secretary of the Board of Governors. The funds were kept in the Indore Treasury and were operated as an Excluded Local Fund, the audit being conducted on official lines by the Accountant-General, Central Revenues, Delhi.

This system of accounts and audit proved in practice to be very cumbersome and very time-consuming. Further it was not in accord with the principles on which the Institute was founded and conducted, namely, a research centre, on the lines of the Sugar Experiment Stations of Java, maintained and governed by its own subscribers. It has been a frequent reproach in India and other parts of the tropical possessions of the Empire that most of the agricultural research work in the past has been carried out in Government institutions by official agency. In western countries, such work is organized on quite different lines. Most of the research centres are autonomous bodies, financed, in part at least, by benefactions of various kinds. This arrangement not only affords ample scope for rapid development but also tends to make the bond between the research workers and the actual cultivator much closer and more intimate. Further, it helps to remove the work of rural development from the sphere of political discussion. The Institute of Plant Industry at Indore was erected and is financed entirely by subscriptions and is controlled by the subscribers. Moreover, it furnishes an example of the union of diverse interests for a common purpose. It is obvious, therefore, that the official control of the funds was an anomaly, which tended to obscure the fact that this Institute marks a real advance in the conduct of agricultural research work in India. For these reasons, it was decided in 1928 to terminate the system of accounts and audit under which work started in 1924. On July 25th, 1928, the Institute was incorporated under the Societies Act and the funds were transferred to the Imperial Bank. Payments are now made by cheque and the accounts are audited on the spot by a firm of Chartered Accountants. These changes have more than justified expectation. The Memorandum of Association and the Rules of the Institute are printed in full as an appendix (page 68).

Rapid progress has been made in the development of the Institute. The first meeting of the Governing Body was held on November 24th, 1924, when a large number of preliminary matters were settled. The leased area was handed over by the Holkar State on December 30th, 1924; the building of the Institute was commenced in February 1925, and the first crop of cotton was sown in June of that year. During the

last two years, the following States of Central India and Rajputana, in order of date, have joined the scheme—Tonk, Bijawar, Barwani, Jhalawar, Bikaner, Jaipur, Rewa, and Bundi. The number of Contributing States has therefore grown from eight to sixteen and the annual contributions from Rs. 20,800 in 1924 to Rs. 44,550 in 1929. In addition to this increase in the number of Contributing States, benefactions of the total value of Rs. 103,142 have, up to the time of writing (June 1929), been made. A list of these will be found on page 79.

The general objects of the Institute and the lines of work to be undertaken must now be summarized. These are:—

(*a*) the establishment of an agricultural research Institute for the Indian Central Cotton Committee at which fundamental investigations on cotton can be undertaken. In addition a critical study of cotton growing on the black soils of India, and the production of improved cottons for Central India and Rajputana, both for dry and for irrigated conditions, will be undertaken.

(*b*) the training of post-graduate students nominated by the Central Cotton Committee.

(*c*) the provision of an agricultural centre for the States of Central India and Rajputana, which will serve as an object lesson for the development of this portion of India and at which officers and cultivators, nominated by the Darbars, can be trained.

CHAPTER II

THE INSTITUTE OF PLANT INDUSTRY, INDORE

At the moment new experiment stations are being started at a number of places in the Empire. More are in contemplation. A few already exist. In hardly a single instance has anyone published a detailed account of these centres, of their purpose, their equipment and their cost. In order to obtain any real information about any of these experiment stations, it is necessary to visit them. Hardly any literature on the experiment stations of the Empire exists.

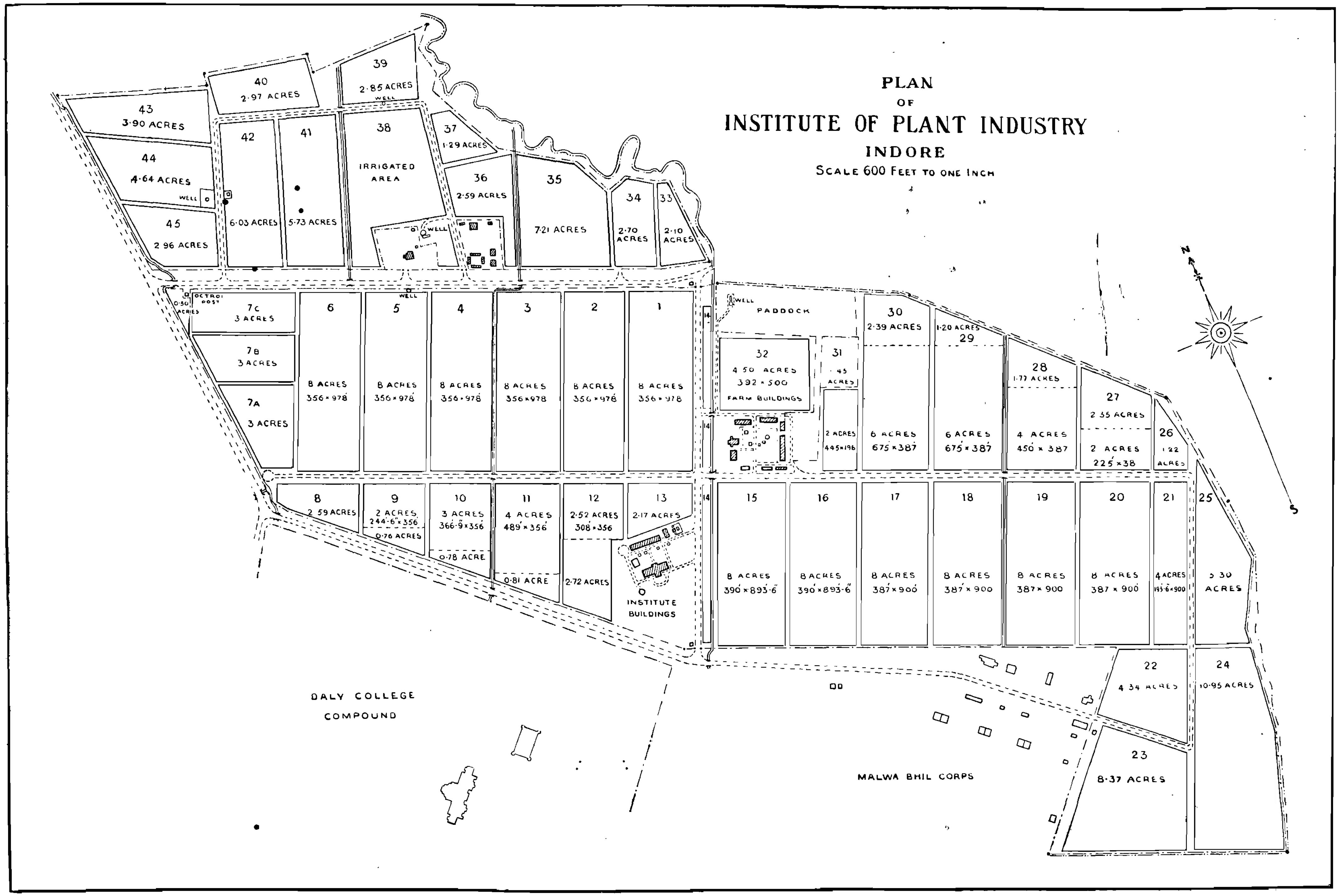
Indore is the third experiment station for the study of crops we have had to create since we started work in India in 1905. In this we have embodied the experience obtained at Pusa and at Quetta, as well as the results of our travels during the last thirty years. A statement of the considerations underlying the choice of site of an institute for the study of crop-production, as well as the details relating to the lay-out, the equipment and the cost may prove to be of use to workers and to administrators in other parts of the Empire.

The Selection of the Site

In the selection of the site of a research institute for crops in the tropical possessions of the Empire, a number of considerations have simultaneously to be borne in mind. The area selected must be typical of a large tract of country, it must contain within itself all the types of soil ordinarily met with in this tract, and there must be ample supplies of irrigation water. The supply of labour (including child labour for plant-breeding work) must be adequate and capable of expansion as the work develops. Such an experiment station must be easily accessible by road and rail, it must be close to a large town so that such amenities as schools, hospitals, post and telegraph offices, a market for the purchase of ordinary commodities and for the sale of surplus produce are all automatically provided. The acquisition of a suitable area close to a centre of population will, in the majority of cases, add to the capital cost, nevertheless such a site may prove to be the cheapest in the end. Even when the site is only a few miles from a large town, the experiment station suffers from great disadvantages. Land at a considerable distance from a large town, and far removed from good roads and the main railway systems of the country, is

naturally cheaper and easier to acquire than a suitable area close to a large city. The saving in the initial cost is, however, often dearly purchased. A large amount of time, energy and money is consumed by the staff in getting to and from the nearest main railway line. The purchase and transport of supplies and of produce suffer from a similar disadvantage. Visitors must of necessity be few. Every ordinary amenity required by the staff, such as schools, hospitals, post offices and domestic supplies, has to be created on the spot at great cost. There is no social intercourse for the workers beyond that provided by the experiment station itself. For these reasons the pay of each member of the establishment is higher than would otherwise be the case, while long periods have to be spent on leave in connexion with family affairs. Apart from the general loss of efficiency, which follows from these causes, there remains a still graver disadvantage. The workers tend to lose a proper sense of proportion, and difficulties of all kinds arise. In the selection of a site for an experiment station, therefore, the greatest care must be taken to keep in mind not only the agricultural but also the human factors which are involved.

Thanks to the assistance rendered by the late Mr. Bernard Coventry and by Sir Oswald Bosanquet, a site which fulfilled all the conditions necessary for the new Institute was found at Indore in Central India. An area of 300 acres (with metalled roads on two sides), which included most of the types of black cotton soil and which was provided with ample possibilities for the development of well-irrigation, was selected. This area adjoins the Daly College and the Residency and is close to the city and to the cotton mills. The neighbouring Malwa Bhil Corps lines provide an ample supply of labour. The land was offered by the Holkar State on lease for 99 years at a nominal rental of Rs. 300 per annum. In this way all the expense and trouble in acquiring a suitable site were avoided. The Indore State attached one condition only to this very generous offer. The Darbar retained civil and criminal jurisdiction over the leased area. Since the land was acquired on December 30th, 1924, an important concession has been granted by the Holkar State. An exemption from all State regulations, relating to supplies and to the sale and movement of produce, has been granted to the Institute. The relations with the State authorities from the outset have been of the most cordial nature, and the Darbar has always been ready to further the work and the development of the Institute in every way possible.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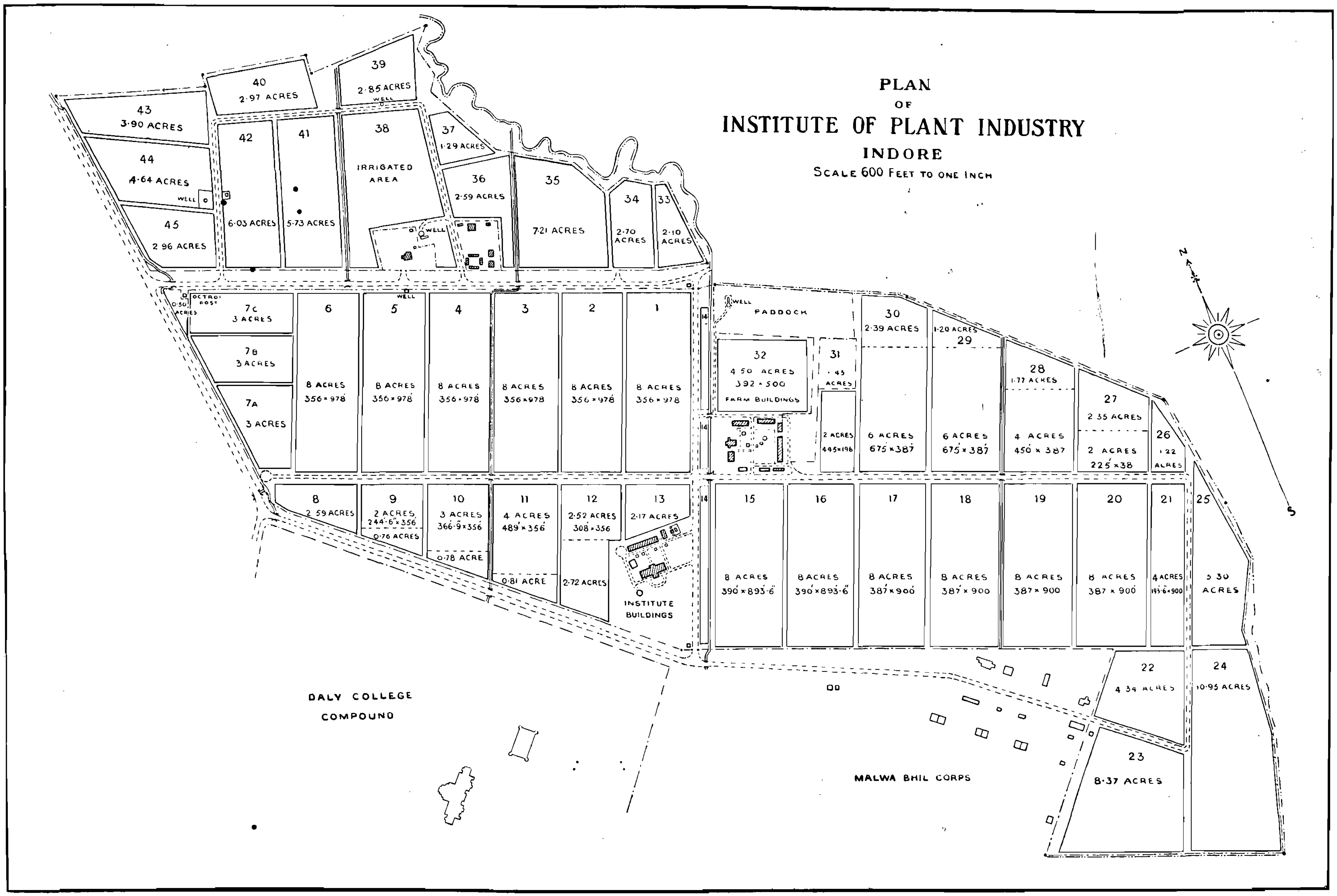
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MALWA BHIL CORPS

The Lay-out of the Leased Area

Two general ideas have been kept in view in the general lay-out. The primary object was the creation of a modern experiment station for the study of cotton and related crops. A secondary purpose was the provision of an area of improved land, which would be of use in the agricultural development of the Central India and Rajputana States. It was felt that progress, in the improvement of the territories of the Contributing States, would be greatly facilitated if the Darbars could see for themselves how their dominions could be developed, and their revenues increased by following a consistent policy of rural reconstruction for a single generation.

An examination of the leased area showed that it would be necessary, first to protect the experiment station on three sides from the drainage of high-lying areas, and then to provide a suitable system of surface-drainage for the various plots. In the past, the run-off from the higher lands had led to two results. In the first place, about one hundred acres of the best land had been water-logged during the rains to such an extent that it had been abandoned by the cultivators and allowed to fall under grass and scrub. In the second place, the uncontrolled drainage had produced a number of erosion nullahs which not only lowered the fertility but rendered the land very uneven in cropping power. The run-off from the high-lying areas on the east, south and west was first dealt with. This water was carried through the area to the nearest drainage line by means of three small drainage canals. The experiment station itself was then provided with a system of surface-drainage, so that each plot dealt with its own rainfall only. The nature of these arrangements will be evident from the general plan (Plate II). Full details of the system and of its results are given in Chapter IV. The installation of surface-drainage was followed by a marked improvement in fertility.

After surface-drainage had been provided for, the next step was the provision of metalled roads so that rapid and easy access in all weathers to all parts of the experiment station was possible. Good communication is an important matter in all experiment stations. On the black soils of India, where the soil becomes so sticky during the rains that for long periods the land is impassable, good metalled roads are essential. To provide the necessary access, no less than 20,062 feet of roads had to be constructed, together with the necessary bridges and culverts. This item of the lay-out, which cost Rs. 32, 847 (Rs. 8,645 per mile), was rendered possible by a donation from

the Central Cotton Committee. These roads have proved a great boon. They pay a substantial annual dividend—in the form of time and energy saved. They have enabled important visitors, who are frequently pressed for time, to gain a good idea of the Institute and of the work in progress in little more than an hour.

The results of the lay-out of the 300 acres are as follows :—

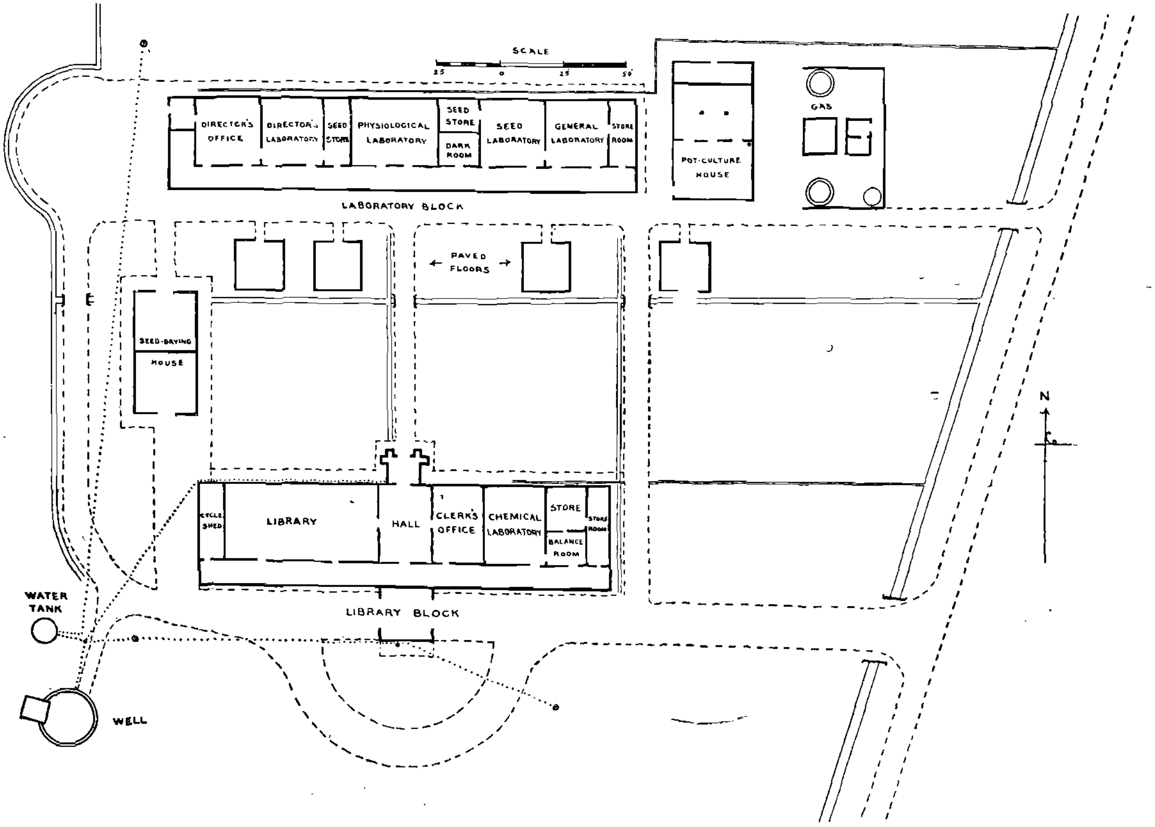
		Acres
Total area under cultivation (plots 1–45) including 16 acres commanded by existing wells	..	250·38
Grazing area east of the Bhil Corps road	..	16·25
Ecological plots in blocks A and B ..	..	2·43
Model village, cattle paddock, laboratory compound, farm-buildings, compost factory, roads and paths, grass borders of fields, drainage canals and surface drains ..	..	30·94
TOTAL	..	300·00

At least half of the 30·94 acres devoted to buildings, roads and so forth yields a good crop of grass so that the area lost in the lay-out is less than five per cent.

The grading of the individual fields was the third and last operation in preparing the area for experimental work. This involved the dressing of the surface so that all the ridges were removed, all the low-lying areas filled up and all erosion prevented. At the time of writing (June 1929) a good deal of progress has been made in the grading of the fields and it is expected that by the end of 1930 the work will be completed. Simultaneously with the preparation of suitable experimental fields for dry cultivation, three areas have been laid out for well-irrigation on improved lines. These three areas are numbered 13, 32, and 38 on the general plan and comprise 2·17, 4·3, and 9.55 acres respectively.

The time necessary to transform an area of rough, undrained land, for the most part under grass and scrub, into a modern experiment station, on which critical work on crops can be undertaken, is not always realized. Although we brought to this task a considerable amount of experience, and we have been most fortunate in our Governing Body and in its first President and have received the most generous financial assistance from the supporters of the Institute, four years have already been taken up in the preliminary work which will not be

PLATE III



PLAN OF LABORATORIES

completed till 1930. In that year all the fields will be suitable for experimental work.

THE INSTITUTE BUILDINGS

Three sets of buildings had to be erected, namely, the laboratories, the farm-buildings, and a model village (for a portion of the staff, for visitors, and for the ploughmen). In addition five lodges, near the entrance gates, were provided for the small force of military watchmen which is maintained. Thanks to the assistance of the Hon'ble Sir Reginald Glancy, K.C.I.E., Agent to the Governor-General in Central India from 1924 to 1929 and the first President of the Governing Body, the Institute was saved the great cost of erecting a residence for the Director. The former Indore Residency was placed at the disposal of the Institute for this purpose. The old *Thagi* jail was also handed over rent free for conversion into quarters for ten members of the staff and students and for four servants. The necessary alterations were carried out at a cost of Rs. 6,000. As no buildings, suitable for laboratories or farm-buildings, were available at the site, these had to be designed and created. Messrs. A. E. Joyce and H. A. Hyde, M.C., Superintending Engineers of the Central India Agency, very kindly agreed to design and erect these buildings from our line plans, thus saving the Institute a considerable sum of money. Throughout the period of construction, the officers and subordinates of the Public Works Department have been more than helpful and the Institute owes them a debt of gratitude for much generous assistance.

The advantage of having the farm and other buildings in the centre of the experiment station needs no emphasis but the relative position of the laboratories and farm-buildings required some consideration. It is most essential that the scientific and agricultural aspects of the work on crops should be as closely co-ordinated as possible. In all institutions of this nature, a cleavage tends to develop and opposition between the staff employed on the two aspects of the work often arises. One of the tasks of the Director is to weld these two aspects of one subject into a real working unit instead of a combination in name only. For this reason we wished to place both laboratories and farm-buildings together. Several practical difficulties, however, intervened. The noise and dust inseparable from a farmyard are not conducive to quiet work. The presence of laboratories next to the farmyard is apt to discourage the purely agricultural visitor. Eventually the laboratories and farm-buildings were arranged on opposite sides of the main road, the farm-buildings being to windward.

As the money available for the capital cost was very limited, the buildings had to be kept as simple as possible and their size reduced to a minimum. The proportions and size of the rooms have been found to be very convenient and can be recommended for an Institute which is mainly devoted to research. It should, however, be pointed out for the benefit of future Institutes that it is a mistake to make the initial grant for buildings too low. Owing to wasteful expenditure in the past, it is the fashion nowadays in India to assume that the cheaper the buildings the better the work. Lack of money implies not only simplicity and avoidance of ornamentation but also involves cheap construction. Constant repairs are required; another disadvantage is unnecessary exposure to changes of temperature. To reduce expense and yet provide the accommodation required, the walls of the laboratories at Indore had to be thin and the verandahs rather narrow. This tends to make the rooms rather hot in summer and to accentuate the difference between night and day temperatures, a great disadvantage for certain classes of scientific work. Considering the number of years that buildings last and the fact that when once erected any faults of construction cannot be rectified, extreme economy in buildings should be avoided in the future. An additional half lakh of rupees would have made all the difference in the Institute buildings.

The laboratories. The laboratory buildings (Plate I) comprise two parallel blocks, 100 feet apart, facing due north. This was found to be the most convenient and cheapest method of obtaining north light in all the rooms. The arrangement has proved to be very convenient in practice. It avoids the noise inseparable from long corridors or verandahs. The space between the buildings has been utilized to provide various conveniences for out-door experimental work in plant-breeding namely, four paved drying floors, each 20′ × 20′, two of which have been provided with small electrically driven gins for dealing with the seed-cotton of single plants and of small cultures. On the west side of the quadrangle is a wire-netting drying house, 50′ × 25′, in which the produce of experimental plots can be kept between the operations of harvesting and threshing, and where samples of seed can be dried. A pot-culture house, with a saw-roof for physiological and chemical experiments, has been erected next to the botanical block. Water is supplied to the various laboratories from a water tower, 50′ high, the storage tank of which is filled from an adjoining well. This also furnishes irrigation water for the laboratory compound and for plot 13 (2.17 acres in area), which has been set aside for the

PLATE IV

THE LIBRARY

small cultures required by the laboratory workers. Gas is made from kerosine oil by a small Mansfield plant. All the rooms are provided with electric light and fans and with arrangements for connecting the current with small laboratory motors. The general arrangements of the laboratories are shown in the plan (Plate III).

The library block consists of the library, 60′ × 30′, the small entrance hall, the office, chemical laboratory, balance room and two store rooms. The verandah on the west side has been enclosed as a bicycle shed. The library (Plate IV), which owes its inception to a grant of Rs. 5,930 contributed by the following States: Datia, Dhar, Dewas, S.B., Jaora, Ratlam and Sitamau, now contains about 5000 volumes and subscribes to about 80 periodicals (see page 77). Besides serving as a reference library for the staff and students, it forms a convenient centre of information on agricultural matters for the States of Central India and Rajputana. All papers and books which bear on the local agriculture are being collected, and every effort is made to keep the library up to date and to make it useful and interesting to visitors from the Contributing States. Appreciation of the library facilities offered was soon shown by demands for the loan of books. As it was impossible to comply with these requests without seriously interfering with the work of the Institute, a small lending library has been started. This is maintained entirely by donations and has proved most useful. Another feature of the library is the maintenance of a bookshelf, for the sale of a few standard works, in English and Hindi, on rural development and of copies of the *Kisan*, a monthly agricultural newspaper subsidized by the Holkar State and assisted by the Institute. The sale of books to visitors was undertaken on account of the great difficulty and delay in obtaining literature of this kind in India, and has proved a most popular feature. Very few visitors leave the Institute without purchasing some book. The interest aroused by a visit to the Institute is thus crystallized and made more permanent. In order to economize space, the library has been so arranged that it can be converted into a lecture hall by merely removing the desk for the current numbers of periodicals and the central table. The west wall has been kept free of furniture and thus serves as a screen for epidiascope pictures. The use of one large room, both as lecture hall and library, has much to commend it and the idea has since been adopted in a neighbouring institution. The chemical laboratory has been fitted up for work on the various aspects of soil science, and particularly for the investigation of questions connected with soil

colloids, hydrogen ion concentration and the supply of combined nitrogen.

The botanical block consists of the large physiological laboratory, 30′ × 30′, in the centre together with a dark room, 15′ × 15′. There are two similar sets of rooms on both sides of the physiological laboratory. Each consists of two rooms, each 25′ × 25′, and a seed store, 15′ × 15′. One set is used by the Director, the Cotton Botanist, the Personal Assistant and the artist. The other set has been placed at the disposal of the assistants and students who are working on genetics. The eastern verandah has been enclosed to form a store room for the botanical block.

The farm-buildings. A great deal of thought was expended on the

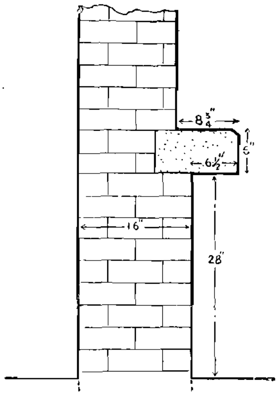
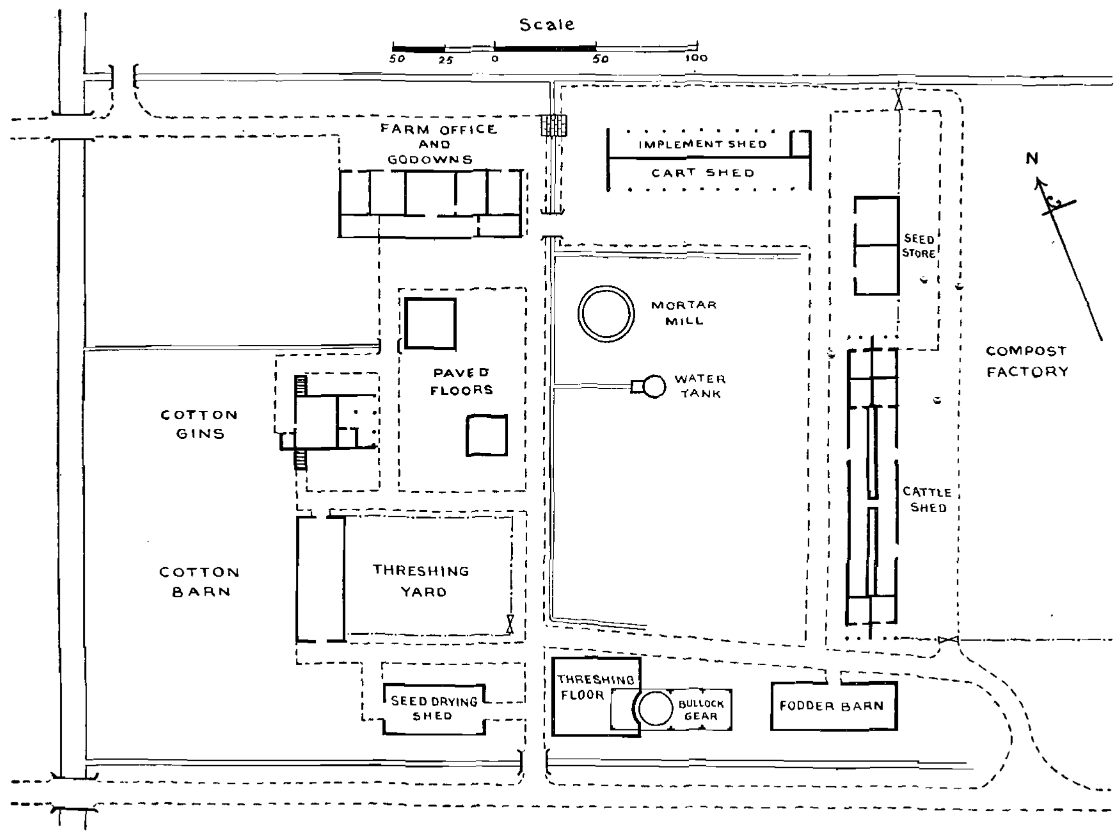


FIG. 1—Projecting course for rendering seed godowns rat-proof

situation and design of the farm-buildings (Plate I) so that the cost of erection could be reduced to a minimum and the work of the farm made as efficient as possible. The orientation and design of the farm-yard and buildings have proved most convenient and so far no improvement suggests itself. The time and trouble spent on this subject have been amply repaid by the efficiency in the working of the farm and by the fact that the farm-buildings (with small modifications in size and so forth) have proved a very suitable model for the various demonstration farms now being started in the Contributing States. The buildings are situated about the centre of the Experiment Station and close to the cross-roads which divide the leased area into four series of plots. They are arranged in a quadrangle, 300 feet square, which is well pro-

PLATE V


Scale
50
25
0
50
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N
FARM OFFICE AND GODOWNS
IMPLEMENT SHED
CART SHED
SEED STORE
MORTAR MILL
WATER TANK
COMPOST FACTORY
PAVED FLOORS
COTTON GINS
CATTLE SHED
COTTON BARN
THRESHING YARD
THRESHING FLOOR
BULLOCK GEAR
FODDER BARN
SEED DRYING SHED

vided with metalled roads and paths and good surface-drainage. The buildings are separated so that there is ample space between each for the movement of produce (Plate V). The farm-office, farm-laboratory and various godowns as well as the cart and implement shed form the northern side. On the east are two seed stores and the cattle shed. The fodder barn, Dutch barn with bullock gear and paved floor and the large wire-netting drying house (50′ × 25′) are on the south side. The west end of the quadrangle is taken up with the cotton barn and the small electrically-driven ginning factory. Inside the quadrangle are the country threshing floor, two paved floors, each 20′ × 20′, on one of which a large cotton gin can be worked, the water tank, mortar-mill and weigh-bridge. The various seed godowns are rendered rat-proof by means of a projecting course of stone work, 28″ above the ground (Fig. 1) and by removable wooden steps. It was decided to employ no power on the farm which could not be commanded by an ordinary well-to-do cultivator. Tractors, steam threshers and electrically driven pumps were therefore avoided. Two forms of power only are employed. Small portable oil engines (5 H.P.) are used for lifting water from the wells which have all been fitted with Boulton elevators. A series of small machines—thresher, fodder-cutter and feed-grinder—has been set up under the Dutch barn. These can be worked either by a bullock gear or by an oil engine.

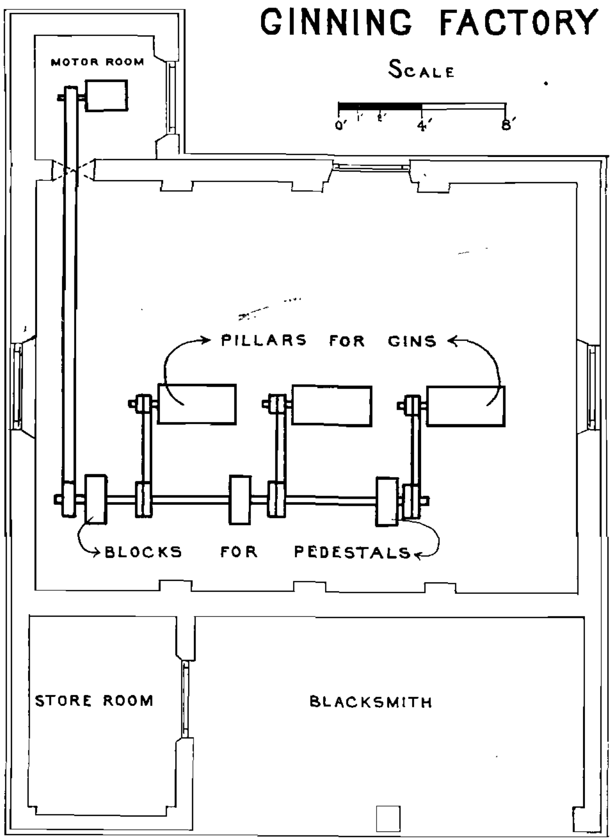
Special arrangements have been made to deal with one difficulty which frequently occurs in the harvesting of experimental plots. It is often impossible to thresh any crop the day it is cut. A period therefore intervenes in which theft and error are possible, especially when several experimental plots are stacked in the same courtyard. Two locked wire-netting houses (one at the farm and one near the laboratory buildings), each capable of holding the produce of an acre of land, have been provided to deal with small plots. A barbed wire enclosure has been made in the farmyard itself for larger plots. The procedure adopted is to cut the experimental plot under supervision and transfer it as quickly as possible to the wire-netting house for drying. Each plot is then threshed in one working period. The chief difficulty encountered in these arrangements is the absence of wind in the afternoon. A special type of wooden fan, driven by the bullock gear, has been designed to meet the difficulty. It is hoped to obtain something cheap which can be adopted by the cultivators.

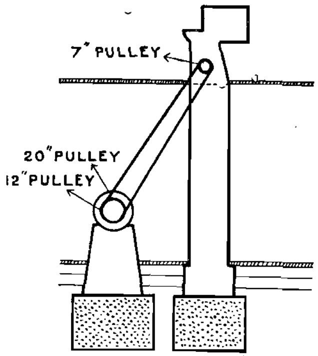
In any Institute dealing with cotton, it is essential to be able to gin the seed-cotton on the spot. A small ginning factory has been

erected in the farmyard. In this case electric power has been used, as the ginning of cotton is not an agricultural operation. The ginning factory, which was designed by Mr. C. R. Palairet, Member for Commerce and Industry, Holkar State, contains three gins on the first floor driven from a counter-shaft by means of a 10 H.P. motor. The gins are fixed on a strong masonry wall, which prevents vibration altogether. The cotton seed is collected in the lower room which also serves as a store room for cotton seed after the ginning season is over. There is a separate entrance for seed-cotton and an exit for the finished fibre, so arranged that it is impossible to mix the two. The details of the ginning factory are given in Plate VI. Single gins for dealing with small plots can be worked on the paved floor in the courtyard. The arrangements for experimental ginning are thus very complete. Single plants can be ginned in the small gins near the botanical laboratories. Plots up to an acre on the single gin in the courtyard, and large plots in the factory itself.

Adjoining the cattle shed is perhaps the most important item of the farm buildings, namely the compost factory and the pits for silage (Plate VII). In order to make the utmost of the waste products—vegetable and animal—of the leased area, the methods in vogue in China and Japan for the preparation of food materials for the crop have been adapted to Indian conditions. The work of cultivation and transport is carried out by twenty pairs of oxen. Two of these pairs are of the Kankrej breed of Gujerat and are used for sowing experimental plots. The remainder are of the local Malvi breed, a type of animal very suitable for agricultural work (Plate VIII).

The model village. The problem of housing the staff and labour close to the Institute has been greatly simplified by circumstances. The fact that the experiment station adjoins a large city has rendered unnecessary the erection of quarters for a large portion of the staff. A great deal of the daily labour is obtained from the adjoining Malwa Bhil Corps lines, for which quarters have already been provided by Government. Only the visitors and a portion of the staff and of the labour have therefore had to be housed. These live in a model village (Plate IX) on the old Sehore road, which runs through the leased area. This village consists of quarters for the assistant in charge of the farm, for two fieldmen, twenty-eight labourers and ploughmen and one watchman. In addition there are nine furnished quarters for visiting officers and six for visiting cultivators from the Contributing States. Five of the furnished quarters for officers were erected by the Holkar





PLAN OF GINNING FACTORY

State at a total cost of Rs. 9,298. The erection of the remaining four furnished quarters for State officers and the quarters for six cultivators was rendered possible by a donation from the Central Cotton Committee. These quarters for visitors are constantly occupied and have proved of the greatest service. Two masonry wells have been provided for the model village, one for drinking water, the other to supply water for washing clothes and other articles.

The Cost of the Institute—Capital and Recurring Expenditure

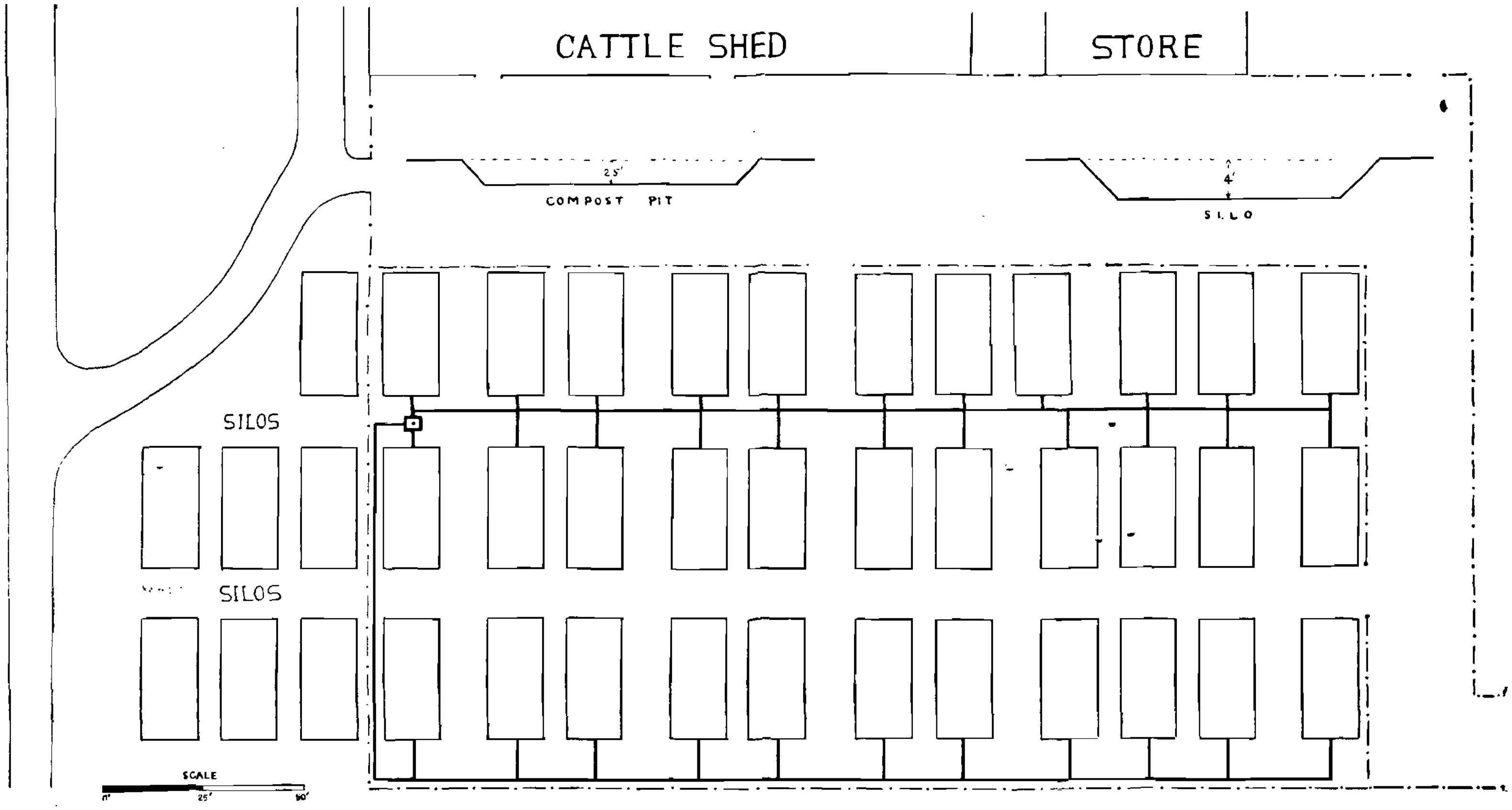
The capital cost of the various portions of the Institute, is given in rupees and sterling (one rupee=one shilling and six pence) in Table I below. The recurring expenditure is now in the neighbourhood of Rs. 1,75,000 (£ 13,125) per annum. The reserve fund approximates to Rs. 10,000. There is a separate trading account, with a capital of Rs. 5,000, for the supply of implements, seed and other articles required by the Contributing States.

Table I. Capital Cost of the Institute

	Rupees			*Sterling*		
	Rs.	A.	P.	£	*s.*	*d.*
Compensation to the Indore Darbar for buildings and wells	10,078	3	0	775	3	11
Laboratories and farm-buildings ..	108,079	5	6	8,313	12	8
Quarters for visitors, labourers, and watchmen	30,931	14	0	2,379	6	0
Alterations to staff quarters ..	6,005	4	3	477	5	3
Furniture and fittings	40,268	8	7	3,097	9	3
Fencing	14,908	4	0	1,146	12	7
Two wells with engines and pumps ..	11,926	14	3	894	10	4
Roads	32,847	1	0	2,463	8	11
Pot culture house	4,297	1	0	322	3	11
Ginning factory and gins	8,046	14	0	603	10	1
Apparatus and chemicals	17,504	8	11	1,312	16	10
Electrical installation and motors ..	6,985	3	0	523	17	9
Bullock gear set	1,203	15	7	90	6	0
Seed bins and drying boxes	660	1	0	49	10	1
Seed drying sheds	3,934	15	0	295	2	6
Neemuch stone threshing and drying floors	2,126	3	0	159	9	3
Work-cattle	6,558	12	3	486	18	1
Book-binding	1,968	13	4	147	13	2
Total ..	308,331	13	8	23,538	16	7

A list is appended of the present staff. It is probable that as the work expands it may be necessary to make one or two extra appointments.

Director of the Institute and Agricultural Adviser to States in Central India and Rajputana, Cotton and Physiological Botanist, five Assistants on Provincial Service pay (Assistant for demonstration work in the States, Personal Assistant, Assistant in charge of field experiments and farm, Chemical Assistant and Botanical Assistant), five Junior Assistants (Plant-breeding, Farm (3) and Botanical), Librarian, Artist, two Clerks, three Fieldmen, Store-keeper, two blacksmiths for the farm, one blacksmith for extension work and the usual menial staff.



PLAN OF COMPOST FACTORY AND SILO PITS

CHAPTER III

INVESTIGATIONS ON COTTON

As the Indore Institute owes its existence to the grants made by the Central Cotton Committee and was founded as an agricultural research institute for work on cotton, it follows that the investigations on this crop take up a great deal of the energies of the staff. The programme of work on cotton,[1] which was adopted in 1924, is given in full as an appendix (page 80). This falls into the following well defined groups:—

(1) The investigation of fundamental questions, the results of which apply to the whole of the cotton work in progress in India.

(2) Genetics, including the improvement of the kinds of cotton now grown in Central India and Rajputana under dry and irrigated conditions.

(3) Improvements in the agronomy of cotton.

It will be convenient to deal with these three groups separately and to record the progress made up to the time of writing (June 1929).

THE INVESTIGATION OF FUNDAMENTAL QUESTIONS

The scope for the investigation of fundamental problems underlying the production of raw cotton in India is very great. Many interesting questions are lying ready to hand which urgently need attention. One of the reasons why these matters have not been studied in greater detail in the past is the fact that, at the best, progress in such investigations must always be slow. Consequently such work is only attempted where the working conditions are favourable.

A classification, on modern lines, of the cottons of India is perhaps the greatest need at the moment. A classification from the point of view of systematic botany[2] has, it is true, already been carried out

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[1] Before actual work on cotton was commenced at Indore, a critical survey of the Indian literature on this crop was made, the results of which form Chapter X, of *Crop-production in India*, Oxford, 1924. At the same time cotton growing on the black soils—in Central India, Bundelkhand, the Central Provinces and Bombay—was studied.

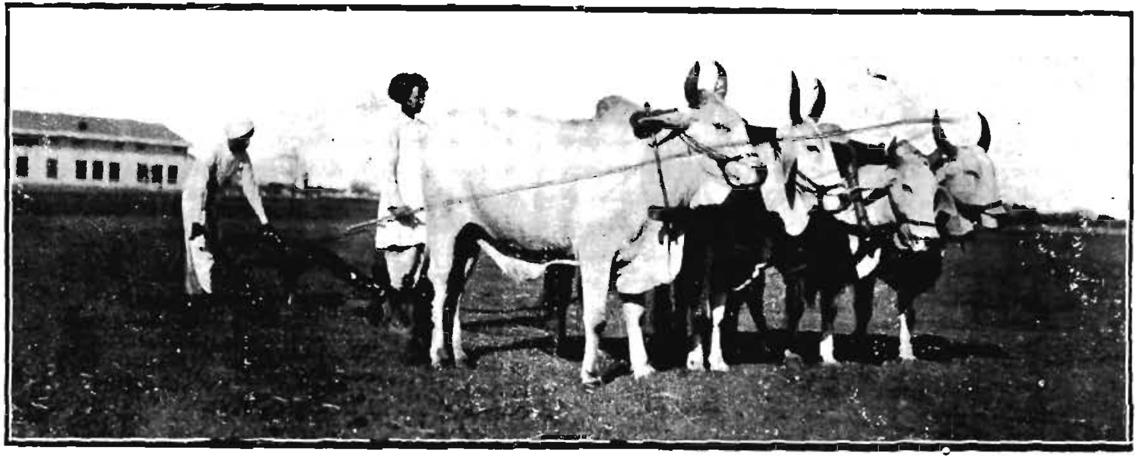
[2] Gammie, G. A.—The Indian Cottons, *Mem. of the Dept. of Agr. in India (Botanical Series)*, ii, 1907.

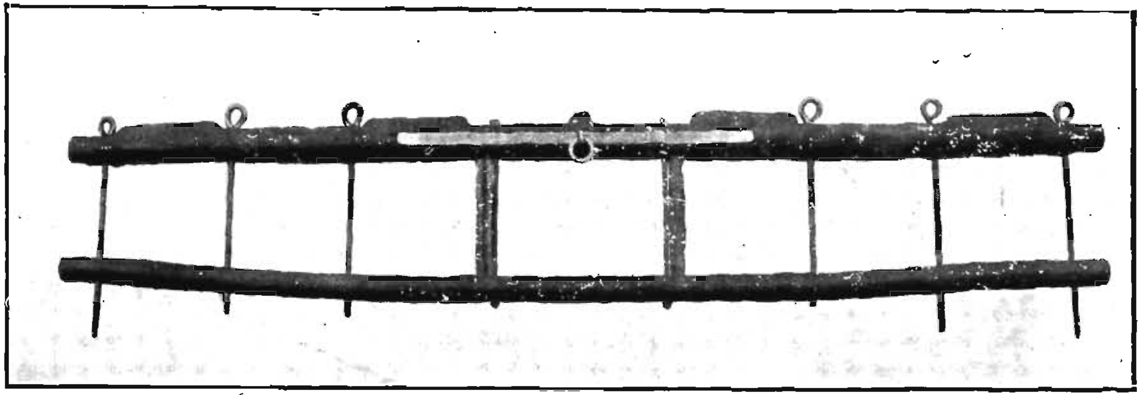
but this is of little use in plant-breeding. The limits of the various Indian species and varieties have first to be determined from a study of living material. After this the unit species, which make up the various varieties, have to be isolated and studied both in the field and in the laboratory. In this way only can the full commercial possibilities of the Indian cottons be ascertained. Material will then be available both for the plant-breeder and for the much needed critical work on the physiology and agronomy of cotton. At the same time a more accurate set of spinning trials will be possible. When the work on the purely Indian forms has been completed, it will be necessary to include the indigenous types met with in other parts of Asia such as Persia, Central Asia, and China. As the collection of the unit species of the cottons of the Orient is being built up, it will be necessary to determine as many of their characteristics as possible, particularly the nature of the fibre, the main facts of root-development and the number and form of the chromosomes. The aim of this classification is to maintain at Indore a collection of unit species of Indian cottons with full descriptions, which will be available at a moment's notice both for workers at the Institute and in other parts of the country. At the beginning, a number of difficulties had to be overcome in the growing of a portion of the material needed in this investigation but now that two areas have been laid out for well-irrigation, the cultivation of late types will not be so difficult.

In one section of this work results of interest have already been obtained. The chromosome numbers of twenty-eight Indian types have been determined by one of the senior research students and a suitable method of procedure has been worked out. All the Indian forms contained thirteen chromosomes very similar in appearance; the four American types examined at the same time all contained double this number. Denham's[1] original results were therefore confirmed and extended. Full details of this work will be found in a forthcoming paper in the *Annals of Botany*.

A preliminary survey of the root-systems of the cottons of India has been completed with a view of working out a suitable method of procedure and of discovering (1) what general differences exist in the types of root-system and (2) the effect of factors like soil-aeration and local water-logging on root-development. These preliminary results will be of the greatest value when a detailed study of the root-system

[1] Denham, J. H.—The Cytology of the Cotton Plant, *Annals of Botany*, XXXVIII, 1924, p. 433.





THE ERADICATION OF KANS (*Saccharum spontaneum L.*)

of the collection of unit species is carried out. Contrary to statements which have been made in India that the knapsack sprayer cannot be employed on black soils to expose the active roots including the root hairs, this method has given good results at Indore. All that was necessary was to design a new type of nozzle for the spraying machines (Fig. 2). Among the results obtained the following are of general interest :—

(*a*) The suitability of *roseum* cotton (a variety of *G. neglectum* Todaro) for black soils appears to be bound up with a most efficient type of root-system which closely fits the soil type as well as the general moisture conditions.

(*b*) The failure of American types like Cambodia, as a rains

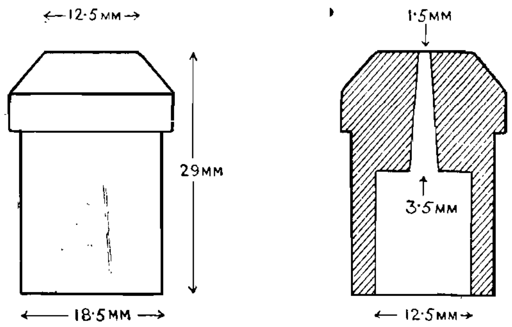


FIG. 2—Nozzle for black cotton soils

crop on black soils, is a direct result of a type of root-system suitable only for rich soils or for irrigated conditions.

(*c*) The response of the root-system of cotton to improved surface-drainage and to better soil-aeration is very marked, thereby explaining the results obtained on ridges in Gujarat.

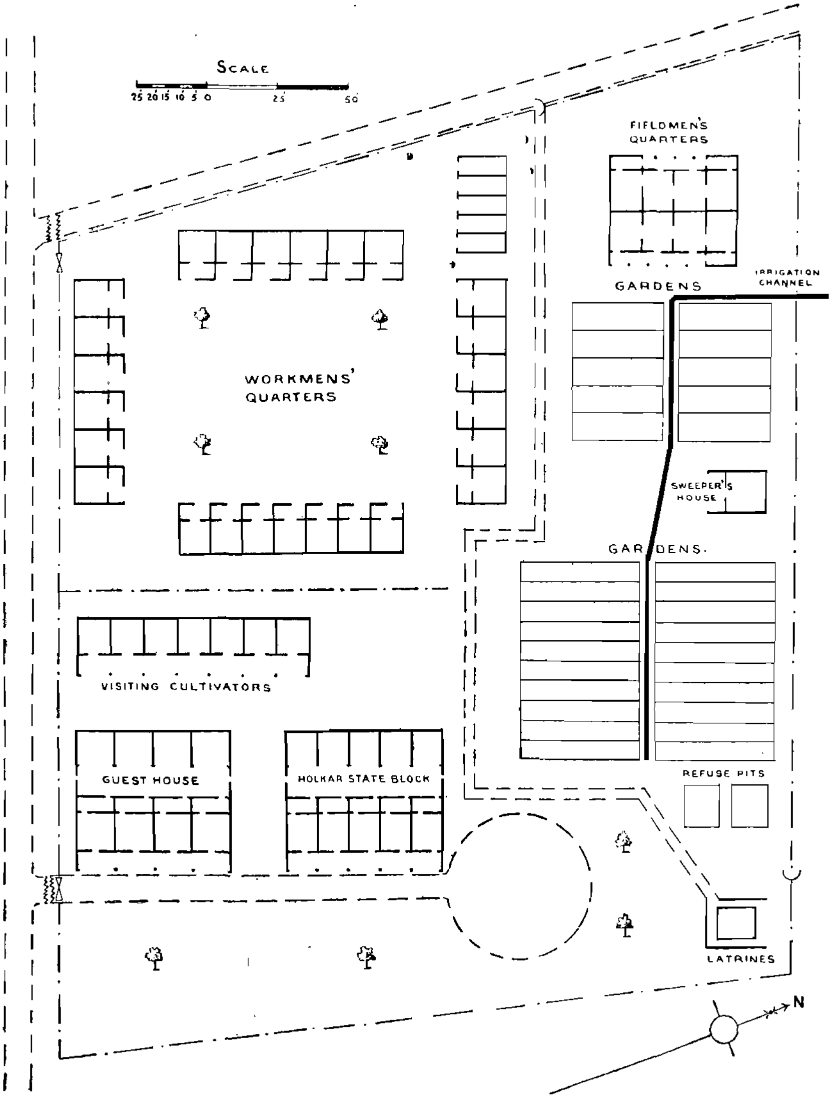
There can be little doubt that much of the plant-breeding work of the future on cotton will concern the life history of the root-system and its relation to the soil type quite as much as the growth of the shoot and the character and amount of the fibre.

The influence of environmental factors on the lint is another subject which is being investigated at Indore. During 1928, a large amount of material was obtained which is now being studied. As is well known, the cotton fibre alters in character according to the soil on which it grows and according to the season. It is very desirable

to discover which factors bring about these changes, which varieties are most easily affected and whether any practical methods exist for improving the uniformity of the fibre of any cotton. It would be most interesting to know what is the cause of the shortening of the fibre of cottons like Cambodia, when transferred from rich irrigated garden lands to monsoon fed conditions. It will be necessary for the plant-breeders of the future not only to produce a better cotton but also to arrange for the improvement of the fibre to be maintained in practice. If this is not done, the establishment of definite grades will be difficult and the cotton industry of the near future, which is certain to demand a more and more uniform product, will not be satisfied. It is expected during the course of this investigation that Balls' results on the development of the cotton hair will be confirmed and extended.

One of the consequences of the fragmentation of agricultural problems in the past is the difficulty of considering together the influence of adverse soil factors on the susceptibility of the plant to disease, and the reasons why a plant in health remains immune to the attacks of insects and fungi. There is a vast literature on some of the fragments of this question but for the most part it concerns various insects and fungi, is unrelated to the essential soil factors, and has been carried out on much too narrow a basis. The wider aspects of disease and immunity are being taken up at Indore and already progress is being made. Evidence is being obtained that the soil conditions necessary, say for an insect epidemic, must begin to operate some months before the actual insect appears and that the sequence of events is somewhat as follows: unfavourable soil conditions lead to changes in the acidity and other characters of the sap and so prepare suitable food for the insect or fungus which thrives just as long as this food supply is available. Favourable soil conditions, on the other hand, bring about a marked increase in the resistance of the plant. Further, insects and fungi do not spread from the susceptible area to the healthy crop alongside. An investigation of the causes of the red leaf of cotton on these lines is being carried out. One difficulty, however, will have to be surmounted in these studies. As the lands of the Institute are brought into order and drained, the general health of the cotton crop is improving to such an extent that insect and other diseases are becoming very rare. It will be necessary to cultivate cotton on a portion of the area in the direction of disease rather than of health, otherwise these interesting investigations will come to an end for lack of material.

PLATE IX



THE MODEL VILLAGE

THE IMPROVEMENT OF THE VARIETY

The improvement of the variety of cotton grown in Central India and Rajputana involves three problems of immediate importance. These are: (*a*) the isolation of a robust, rapidly maturing type with a fibre capable of spinning at least 20 counts[1] which will be suitable for dry cultivation on the Malwa plateau, a tract which formerly produced a far better class of cotton than is now grown, (*b*) an improved type of *roseum* or of some similar cotton for the low lying areas of Central India which adjoin the Central Provinces and Khandesh and (*c*) the discovery of the best type of cotton for well-irrigated conditions.

An improved type of cotton for the Malwa plateau. As a collection of unit species suitable for hybridization was not available in India in 1924, it was decided to obtain as great an improvement as possible by selection and then to proceed to hybridization. A beginning was made in this work in 1925. At that time the greatest difficulty was experienced in finding even half an acre of land free from *kans* (*Saccharum spontaneum* L.) on which the first cultures could be grown. During 1926 and 1927 the number of cultures was increased and in the latter year a beginning was made in growing cottons under well-irrigation. It was not till 1928, however, that plots suitable for experimental work, both for dry cultivation and for well-irrigation, were available. In one respect the growing of a large collection of cottons on unimproved land proved advantageous. All types unsuited to the conditions of Central India could readily be distinguished. Thus the unfavourable soil conditions rapidly reduced the selection ground from which the improved cottons were likely to be isolated. Between 1925 and 1928, the following types[2] have been grown under dry and under well-irrigated conditions:—

Assam. A sample from the Garo hills.

Bombay and Sind. Broach C_1, Broach 6, Selection II, Dharwar I, Dharwar II, three Dhulia crosses (numbered B×1, B×19, B×27) Ghoghari A26, Ghoghari B3, Ghoghari C22, Ghoghari E5, Gadag I, *roseum*, *Mollisoni*, Wagad 4, Wagad 8, Wagad 12, Wagad 14, Wagad white flowered, Wagale, 1027 ALF, 1A cylindrical boll, 1A long boll, 27 WN Sindh, *G. arboreum*.

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1 Cotton fibre is spun into hanks of yarn each 840 yards in length. The number of hanks to the pound is known as the *count*. The finer the yarn, the higher is the count.

2 For the present these types are being maintained under their original labels. This will be continued until the new classification of the cottons of India has been completed.

Central Provinces. Akola 2, Akola 4, *bani, buri, G. neglectum* var. *roseum Kutchica, G. neglectum* var. *verum, G. neglectum* var. *verum Malvensis, G. neglectum* var. *roseum, G. arboreum.*

Madras. Coimbatore I, Cambodia (local), 440, 664, Hagari 25, Karunganni 3, Mungari 274, Nandyal 14.

Mysore. G. herbaceum (naked seeded variety).

Punjab. 4F, 285F, 289F, *G. arboreum, G. obtusifolium, G. Nanking* var. *soudanensis.*

United Provinces. Cawnpore 255, Cawnpore 402, Cawnpore 520, Cawnpore 1031 and 74 unit species sent by the Assistant Economic Botanist, Cawnpore.

Central India. Selections made in 1924 from the local *malvi* crop mostly from Kannod in the Nimawar District of the Holkar State. Selections made in 1924 at Indore from commercial samples of *bani.* Selections made at Indore in 1925 from commercial samples of *roseum.*

As is well known the Malwa plateau produced in the past a very good type of cotton--soft in texture and of moderate length. Of recent years a great deterioration has taken place owing to the influx of *roseum.* The crop as now grown is a mixture of true *malvi* (a variety of *G. neglectum* Todaro), *roseum*, hybrids of these two with a small percentage of *bani* (*G. indicum* Lamk.) and *buri* (*G. hirsutum* Mill). The mixed crop is also late in maturing. After the end of December, damage by rain and frost is frequent so that it is necessary to find an early maturing cotton, the last picking of which can be gathered before the New Year.

Among all the cottons tried during the last four years, the three groups of selections made in 1924 from local *malvi, roseum* and *bani* have stood out from the rest in general vigour and cropping power. All these sets of cultures grew well and set seed without difficulty even in wet years. Of the three groups, the *malvi* cultures have done best at Indore. This variety of cotton appears to be not only well adapted to Central Indian conditions but also to possess qualities likely to be of use elsewhere. One of its most striking characteristics is the high proportion of cotton to vegetative growth. At picking time, the plant appears to be all cotton. Another useful characteristic is its power of resistance to adverse monsoon conditions. The selections made show great promise and the isolation of an improved *malvi* cotton which will ripen early, yield well and produce a much better fibre than the mixture now grown is only a question of a very short time.

A small improvement in *malvi* cotton has already been obtained by mass-selection. Seed of the best cotton available was procured in 1924 from Kannod in the Nimawar District of the Holkar State, where, owing to local transport arrangements between the Holkar State and the Central Provinces, contamination with *roseum* is difficult. Every year this Kannod cotton has been subjected to mass-selection so as to provide the Institute with seed for general sowing. The seed which has resulted is eagerly sought after by the cultivators, and is sold every year to the Rural Development Department of the Holkar State for distribution through the Co-operative Societies. A better crop is obtained than that raised from ordinary seed, while the lint fetches a higher price at the Indore mills. This small improvement has already gained the confidence of the cultivators, and has enabled the Development Department to begin the organization of their seed distribution scheme. Both these factors will help substantially when an improved unit species is available for distribution. The problem then will be to provide sufficient pure seed for starting all the depôts. This difficulty will be partly met by the lease, for seed growing purposes, of the cultivated portions of the Daly College compound, which adjoins the Institute, a matter which has just been satisfactorily arranged.

Selection work on *roseum* and *bani* will be continued in order that improved types of both of these varieties may be available if required. The various unit species of these varieties will also be maintained as material for hybridization.

An improved cotton for the low-lying areas of Central India. At the present time those areas of Central India, which adjoin the Central Provinces and Khandesh, produce the ordinary mixed *roseum*, the produce of which is moved by cart to the Indore market and to other trading centres on the plateau. It is most important to replace the cotton of the low country by a better type at the earliest possible moment. It may be that the improved cotton, isolated by Dr. Youngman, will prove suitable. Dr. Youngman has kindly promised to supply a quantity of seed for trial at three centres in 1929. If, as is expected, the results are favourable, steps will at once be taken to replace the existing *roseum* of the low country by the new type which is not likely to differ very much from the new cotton we hope very shortly to establish on the plateau.

The most suitable type of cotton for well-irrigated land. So far the most promising selection ground for an improved cotton for the well-

irrigated lands in Central India and Rajputana appears to be Cambodia. No other cotton tried up to date appears to have the power possessed by Cambodia of responding to the improved soil and moisture conditions of well-irrigated lands. These results confirm both the work of the late Mr. Bernard Conventry, C.I.E., (who first introduced Cambodia into Central India) and the results now being obtained on the best lands in the Dhar State. Cambodia, as grown in Central India, is, however, a mixture of a large number of types and selection work with a view of isolating the most suitable unit species is now in progress. A comparison of the various Cambodia selections was made in 1928 and there is no doubt that some types suit the black soils much better than others. The lateness in maturity of all Cambodia types is however a serious drawback to the cultivation of this variety as the last picking is often damaged by frost. During 1929 and succeeding years, we propose to try the the effect of ridge cultivation on this variety and to ascertain if any practical method can be found for speeding up growth in the early stages so that the crop can be gathered before the first frost occurs.

There is, however, a more serious difficulty connected with the growing of a long staple cotton on the well-irrigated tracts, the solution of which does not promise to be a very easy matter. If, for example, the well-irrigated lands of Malwa produce long staple cotton and the dry lands another type, the two grades must be baled and sold separately and the mixing of seed and of fibre must be prevented. If this is not done, the full advantage of growing long staple cotton cannot be realized. The recent experience in the Punjab shows how difficult it is to maintain and market two different grades of produce in the same tract. The difficulty can be solved, in part at least, if a single type of cotton can be found which will suit both dry and irrigated conditions. It might even pay in the long run to make some sacrifice for this solution rather than place the locality in the dilemma in which the Punjab now finds itself. Unfortunately, Cambodia does not fulfil this condition. While it responds very markedly to improved conditions it does not stand up to the unfavourable circumstances experienced by the rain-fed crop. Under such conditions *malvi* will give a moderate crop while Cambodia will give nothing. *Malvi* on the other hand does not seem able to respond adequately to the improved conditions of well-irrigation. This particular problem will have to be faced at Indore in the near future. An effort will have to be made to find a cotton which, while able to give a good crop under

COLL.G AND RESEARCH

rain-fed conditions, will also be able to respond to the better soil and moisture conditions of well-irrigation and give yields as high as those obtained with Cambodia. If this could be accomplished, only one cotton need be grown and all the difficulties inherent in maintaining two different cottons in the same area would be avoided. That such a solution is possible is shown by the success of some of the Pusa wheats on the alluvium, both under dry cultivation and under irrigation.

The mixing of cotton varieties. The necessity of maintaining improved varieties of cotton in pure culture is now widely recognized. The greatest care is taken, at many experiment stations, to avoid the results of vicinism and also to prevent the mixing of seed during the process of ginning. A careful search in the literature on cotton, available in the library of the Institute, has, however, failed to discover any mention of two other possible sources of admixture, namely, contamination of the soil with cotton seed used for feeding the work-cattle,[1] and with seed left in the ground from a previous crop. Observations made at Indore during 1926 have shown that loss of uniformity in cotton varieties may arise from either of these causes.

The contamination of the soil through seed from the previous crop, on the black soils of the Malwa plateau, arises not so much from careless picking as from the secondary flowering of cotton, which takes place in March at the beginning of the hot weather sometime after picking is finished. Unless care is taken to remove the old cotton stalks immediately after the last picking, a number of fully developed cotton seeds find their way into the soil, and germinate after the first rains in June and July.

It was observed after a fall of 0·55 inches of rain on June 24th, 1926, that numerous cotton seedlings appeared on the surface of the manure pits and also to a smaller extent on land which had not been under cotton during 1925, but which had recently been manured with farm-yard manure. These seedlings, in all probability, arose from the cotton seed used in feeding the work-cattle. This was fed whole up to April 1926, after which it was crushed in a mill before it was given to the animals. Contamination of the fields by these stray cotton seeds might have arisen in two ways: (1) through seed falling on the

[1] In 1915, feeding experiments with wheat and gram were carried out at Lyallpur (*Agr. Jour. of India*, X, 1915, p. 353) in which as many as 20 per cent of whole wheat grains germinated after passing through the work-cattle.

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floor of the cattle shed and so finding its way into the manure pits, and (2) from seed which passed through the stomachs of the oxen.

To determine to what extent viable cotton seed can pass through the alimentary canal of a working bullock, six of the oxen doing ordinary work were fed with uncrushed cotton seed for ten days: 2 lb. being given to each animal daily. The experimental animals were kept separate from the remainder, and the dung passed during each night was collected and washed every morning for twelve days. In all, 11,571 complete cotton seeds were found in the dung; a nightly average of about 160 seeds for each animal. These seeds were sown at once in earth. Germination was considerably delayed and only 115 seedlings (one per cent of the seeds sown) were produced. The remainder failed to grow but proved an irresistible attraction to dung beetles, which rapidly devoured them although they were planted in soil in the ordinary way. A control plot of 500 seeds, from the sample of cotton seed used in the feeding experiments, gave a germination capacity of 66·8 per cent. The passage of the cotton seed through the alimentary canal therefore greatly lowered the vitality of the seed.

These results indicate the need of crushing or boiling all cotton seed before it is fed to the work-cattle employed on experiment stations and seed farms in India concerned with the improvement of cotton and the growth of pure seed for distribution to cultivators.

CHAPTER IV

IMPROVEMENTS IN THE AGRONOMY OF COTTON

A critical survey of the cotton investigations in India of the past twenty years discloses the fact that very little has been done on the study of cotton growing, and on the various agronomic and soil factors involved. In the early years of the present century, the problem of helping the cotton grower lay in finding the line of least resistance. He had to be provided with some simple improvement by which his confidence could be gained. The line of advance lay in the improvement of the variety and in the distribution of pure seed. The possibility that various soil factors might limit the growth of the cotton plant naturally received little or no attention. The time has now come to take up this side of the problem in earnest. A little reflection will show that improvements in the actual growing of the crop must be an important factor in the Indian cotton problem. *It is the weight of cotton fibre produced on every acre of land which really matters* to the cultivator, the merchant and the spinner. This amount of cotton per unit of area is limited by the conditions under which the cotton plant grows. Improved varieties give some increase in the total yield but such results are small compared with the enormous increment made possible by better agricultural conditions. By improving the agronomy of cotton on the black soils, it is possible to double the acre yield. By merely changing the variety, the increase in the crop is often not more than ten per cent. Moreover, the soil factors, which limit the growth of the ordinary cotton crop, will also affect any improved variety. The best results on cotton will therefore be obtained, not by following the methods of the past, but by breaking new ground. The soil factors involved in the growth of the cotton plant, particularly on the black soils, must be considered along with the improvement of the variety if the great possibilities of the situation are to be realized. In other words, *the cotton work of the future must be a well balanced combination of agronomy and genetics with soil science.* A somewhat similar policy has been in operation for some years at the Pasoeroean sugar experiment station, the fruits of which are to be seen

in the present impregnable position of the Java sugar industry.[1] The need for the safeguarding of the Indian cotton industry is as imperative now as the re-organization of the Java sugar industry was, when the competition of beet sugar became acute some thirty years ago, and when varieties susceptible to disease were being grown. In the world of cotton, artificial fibres are already on the horizon. The competition from other countries has for some time been an important factor in the Indian cotton trade. The present position can be met provided ample supplies of raw material, at a reasonable price, are forthcoming. If, as is certain, the acre yield of raw cotton in India can be doubled during the next twenty years, the cotton grower, the merchant, the spinner and the shipper will all be placed in as strong a position as the Java sugar industry is to-day. The simplest solution of the Indian cotton problem appears to lie in a greatly increased output of seed-cotton per acre. This is easily possible provided science is effectively brought to bear on the production of the raw material. Once the great possibilities of the cotton soils of India are realized in practice, everything else will follow. It has therefore been decided to make cotton agronomy one of the important subjects of research at the Indore Institute. The work will be greatly assisted by a generous donation from one of the merchant princes of India—Sir Sarupchandji Hukamchand—who has been so impressed with the importance of this aspect of the subject and with the results already obtained at the Institute that he has very generously founded an all-India studentship of the value of Rs. 150 per month. This will be known as the Irwin studentship in cotton agronomy and will be open to distinguished graduates in science of the Indian Universities.

The progress made in the study of the factors, which limit the production of raw cotton on the black soils, will be described in the present chapter. As soon as work was begun, it was found that at least four soil factors seriously limit the growth and yield of the cotton plant on the black soils. In order of importance these are : (1) the loss of fertility due to perennial grasses of which *kans* (*Saccharum spontaneum* L.) is the most important, (2) the absence of any control of the monsoon run-off during the rains, (3) the lack of sufficient permeability during the second half of the monsoon due to the excessive development of soil colloids, and (4) the low content of organic matter in these

[1] Report by the Right Honourable W. G. A. Ormsby Gore, M.P. (Parliamentary Under-Secretary of State for the Colonies) on his visit to Malaya, Ceylon, and Java during the year 1928, (Cmd. 3235), H.M. Stationery Office, London, 1928.

soils. All four of these factors influence the growth of cotton in much the same direction namely, by depriving the plant of combined nitrogen. This deprivation is sometimes direct, sometimes indirect. The final result is however the same—a slow-growing, stunted plant which cannot possibly bear a heavy crop. Anyone who compares the luxuriant cotton, on the rich garden lands of the Peninsula or on the best tracts of north-west India, with the miserable produce of the average field on the black soil areas in a wet year cannot fail to be impressed by the dwarfing effect of an unfavourable environment. When it is further realized that these miserable looking plants produce the bulk of the raw cotton of India, the case for the scientific study of cotton growing needs no argument.

THE ERADICATION OF PERENNIAL GRASSES

A large area of the black cotton soils nourishes perennial grasses instead of cotton. Particularly is this the case in Central India, Bundelkhand and the Central Provinces, where the yield is often reduced by at least a third. In wet years, these grasses often thrive to such an extent that for many years the fields go out of cultivation altogether. Two perennial species are largely responsible for the damage. The most injurious is *kans* (*Saccharum spontaneum* L.),[1] a species allied to sugar-cane, with thick underground rhizomes which grow very rapidly as soon as the rains break and deprive the surface soil of most of its combined nitrogen. Another species—*kunda* (*Ischaemum pilosum* Hack. Monogr.)—is exceedingly common in the areas of Central India bordering the Central Provinces and Khandesh. The implements in use by the cultivators only keep these grasses in check. They do not eradicate them. In consequence, the cotton fields are permanently infested with perennial weeds, which always take a heavy toll of the cotton crop and, in unfavourable years, put the land out of cultivation altogether. At the moment over a large portion of the chief cotton tract of India, *kans* is king and the cultivator is his subject. The fact that *kans* was fully established on the leased area, when the land was taken over in 1925, forced this subject on our notice and brought home to the whole staff of the Institute the necessity of devising some simple method of dealing with this common pest.

A study of the life-history of this species was begun in 1925, the

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[1] Howard, A.—The eradication of *kans* (*Saccharum spontaneum* L.), *Agr. Jour. of India*, XXII, 1927, p. 39.

results of which will be published separately during the present year. At the same time attempts were made to free the area from this weed. The first trials were made with heavy, soil-inverting ploughs (Sabul and C.T. turn-wrest) but the cattle power required was excessive and the output of work was small and unsatisfactory. The employment of the tractor and the steam plough was out of the question, as the use of such costly implements would for all time effectively prevent the Institute from obtaining any influence with the cultivators. When the cost of an implement approaches the purchase price of a small village, the cultivator argues thus : Why cultivate at all ? Why not buy a village, become a *zamindar* and live comfortably on the rents ? Some simple method of eradication, within the means of a well-to-do cultivator or of one of the primary co-operative credit societies, had, therefore, to be devised. The solution was found in the use of an American ridging plough (from which the wings and sole have been removed) drawn by two pairs of oxen walking abreast on a single yoke (Plate VIII). Four oxen, working together on one yoke, are much more effective than two pairs on ordinary yokes walking in tandem. In the first case, co-operation is the order of the day, in the second case non-co-operation is the rule. Further when four cattle work abreast, only one individual is needed to drive them and so the arrangement saves one man. The *kans* eradicating plough can be adjusted for depth and is attached to the yoke by a chain 13′ long. In this way the line of draught passes through the centre of resistance and the plough runs easily to a maximum depth of eight to nine inches. The soil is lifted not inverted and no interference with levels takes place. A little over half an acre of *kans* infested land can be ploughed to a depth of eight inches in a day by one of these sets. The best results are obtained when the land is ploughed for the first time as soon as possible after the active growth of the weed begins in the early rains. As soon as fresh shoots begin to appear, the land is cross-ploughed. Later in the rains one further ploughing at the most is necessary. After this any weak shoots which are produced must be dug out with the *kodar* (Fig. 3) as soon as they appear. If this procedure is followed, the rhizomes still in the ground die before the beginning of the next rains and the field can be freed from *kans* in one year.

The *kans* eradicating outfit, devised at Indore, formed one of the working exhibits at the Poona Agricultural Exhibition in October 1926, when it attracted wide attention. A few sets were sold. Since that time the plough has been improved and the price reduced so that the

complete outfit (consisting of plough, yoke and chain) is now retailed at Indore for Rs. 50. These are now purchased in lots of 100 and re-sold to applicants. Between August 1928 and the time of writing (June 1929), 64 of these complete sets have been sold.

During the coming year, a wall map, illustrating the life history of the *kans* plant, the damage it does to crops and the method of eradication will be prepared and issued for use in village schools, by co-operative societies and by the revenue staff of the Contributing States.

THE CONTROL OF THE MONSOON RAINFALL

For at least three months before the break of the rains in June, the black soils are subjected to high temperatures and to intense drought.

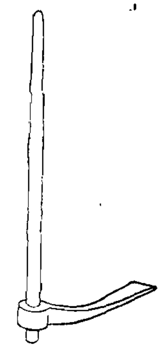

FIG. 3—A *kodar*

Wide cracks are formed and the moisture content of the upper soil is reduced to a minimum. The early monsoon showers are entirely absorbed and there is no run-off until the surface soil is saturated. After this stage is reached, the heaviest falls frequently occur. The saturated soil ceases to absorb more moisture. The surplus rainfall begins to scour the surface and the phase of soil-erosion, accompanied by local water-logging, ensues. As no system of surface-drainage in these areas has been provided, the run-off prepares one for itself. The country is intersected by deep nullahs which throw out minor antennae into almost every field, by which a large portion of the fine soil and a good deal of the organic matter are drained away. Nature's system of drainage in the black soil areas of India resembles a huge cancer, which slowly absorbs the life-blood of the country-side. The loss of

fine soil and of organic matter by erosion is only one of the consequences of this want of scientific drainage. The surface of large areas becomes water-logged for long periods, de-nitrification takes place and growth stops. On the black soils there is no attempt on the part of the cultivators to regulate the monsoon rainfall and to command the situation. There is, however, no reason why this state of things should continue.

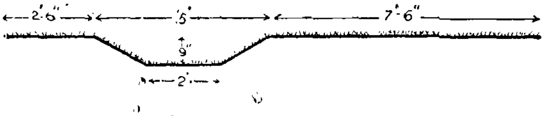

FIG. 4—Surface drain and grass borders

Every effort should be made to stimulate the cultivator to remedy this deplorable state of affairs. A system of surface-drainage, combined with the protection of low-lying areas, has been devised at the Indore Institute which is well within the means of the ordinary villager.

When the leased area was taken over in 1925, more than half the land was under rough grass and scrub on account of the fact that it was too wet in the rains to be brought under plough. The portion

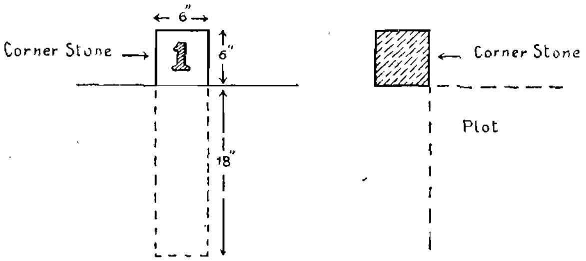

FIG. 5—Corner stones for plots

under cultivation had suffered considerably through scour and a number of erosion nullahs were being formed. The first task was the protection of the lowest portion of the area from the run-off from the Bhil Corps lines, the Daly College compound and the Residency area. For this purpose, three small drainage canals, on the Italian principle, were constructed to carry this drainage through the area and collect the local run-off at the same time. The land was laid out in suitable fields, each of which was provided with shallow trenches with

grass borders to remove its own excess rainfall. In this way the area was protected from outside water and a rough and ready system of local drainage was provided for each field. Wherever possible, rectangular plots, each eight acres in area, have been made. Between every two plots there is a surface drain with grass borders and a grass strip eight feet wide, which serves as a fair weather road for the transport of produce and manure (Fig. 4). The plots are de-limited by numbered furlong stones, four inches in section and two feet long (Fig. 5). These are sunk to a depth of eighteen inches. The inside corners mark the boundaries of the actual cultivated area. These arrangements greatly facilitate the current work and also the laying-out of experimental plots and cultures.

The grading of the fields is as important as the cutting of the drains. At the beginning, the surface of the various fields was in a

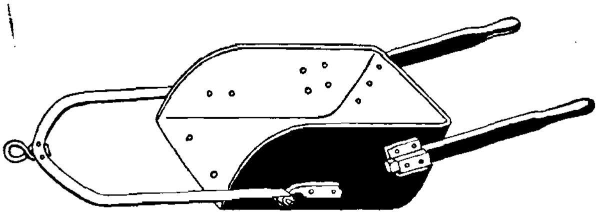

FIG. 6—American leveller

deplorable state. All the old field boundaries were still in existence, shallow depressions were common, a number of incipient erosion nullahs were in process of formation and small trees and shrubs abounded. In some cases, the greatest slope of the land was in the direction of the length instead of in the breadth of the plot. The plots drained longways instead of shortways. In the standard eight acre plots (893·5′ × 390′) this meant that the run-off had to travel 893 feet before reaching the drain. This distance is too great. Water-logging became apparent after 500 feet, a fact which naturally limits the width of a field on such soils. At Indore the run-off should reach a drain after it has travelled about 500 feet. As opportunities occur and labour is available, the proper grading of the fields is being taken in hand so that surface-drainage can take place in the direction of the shorter dimension of each field. Ordinary American levellers (Fig. 6), each holding three cubic feet of earth and drawn by a pair of oxen, are employed for this work. The results obtained have far exceeded expectation. It

has been found that when the work of removing the run-off is evenly distributed over the whole surface of a field eight acres in size, no erosion whatsoever occurs even when a fall of eleven inches in twenty-four hours is received and where the slope is as great as ten inches in 100 feet. One of the conditions of the formation of an erosion nullah on the black soils is the existence of folds in the surface, towards which the run-off from all sides collects. This gives the floor of the fold far too much work to do. Loss of soil by erosion follows as a matter of course which, if unchecked, leads to the formation of a deep nullah with its attendant antennae. The agricultural cancer of Central India is then established which proceeds to feed on the natural fertility of the country side.

Loss of fine soil and of organic matter is not the only consequence of poor surface-drainage. The water-logging of the pore-spaces of the upper foot of soil during the rains is inevitable, unless the run-off can find its way to a drain within a reasonable distance. This water-logging, which is seldom indicated by water standing on the surface, is at once followed by a slowing down and then by a cessation of growth. The foliage begins to turn yellow, leaf-fall occurs and growth is only resumed after the soil begins to dry. Not only is valuable time lost but the excessive development of soil colloids (see page 36) leads to de-nitrification and to the loss of soil texture, the results of which are always apparent in the succeeding *rabi* crop [1] and are not removed till the soil has dried during the following hot weather. Perhaps the most serious result of this water-logging of the pore-spaces is the loss of valuable time both in the *kharif* [2] and also in the *rabi*. The period available for the growth and maturation of the cotton crop in Central India is about 180 days. Of this at least 30 days or over 16 per cent is often lost due to the absence of a system of surface-drainage. This is about equal to the maximum increase possible by changing the variety.

Some idea of the total loss of crop which follows poor surface-drainage will be realized from a study of the following figures obtained at Indore during the cotton and wheat crops of 1928-29. The rainfall of the year 1928 was above the average. Nearly 41 inches were received of which 14 fell in July and 17 in August. The pore-spaces were water-logged for a long period and the cotton crop suffered considerably. The average yield, compared with the normal yield of seed-cotton per acre (200 lb.), is given in Table II. The figures for wheat show how the drainage of the monsoon period affects the following *rabi* crop.

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[1] Cold weather crop.

[2] Monsoon crop.

TABLE II. THE EFFECT OF SURFACE-DRAINAGE ON THE YIELD OF SEED COTTON AND WHEAT

A. Cotton

Plot	Drainage	Area (acres)	Total yield (lb.)	Average yield in lb. per acre
2, 3 and 41 ..	Very bad ..	13·73	1,995	145
4, 8, 10, 12, 16, 19, 20, and 40	Fair to good ..	46·58	17,082	366
15 and 42 ..	Very good ..	6·64	3,388	510

B. Wheat

Plot	Drainage	Area (acres)	Total yield (lb.)	Average yield in lb. per acre
2 and 3 ..	Very bad ..	8	2,960	370
17 and 18 ..	Fair to good ..	16	9,586	600
7C and 31 ..	Very good ..	4	4,020	1,005

These figures show what scope exists on the black soils for simple improvements in the growing of cotton and wheat.

The experimental area has been designed to serve as a demonstration or model of improved surface-drainage and grading, the execution of which is well within the means of an ordinary villager. The grading and surface-drainage of individual fields should be done by the cultivator himself; the drainage canals by combined labour organized by the *panchayat* or by a co-operative society. The results apply not only to the black soils but also to the alluvium and are a natural consequence of the earlier work on this subject carried out at Pusa.[1] The Indore demonstration has already aroused interest. Several of the officers of the Contributing States are keenly interested in the work and intend to adopt the system when new villages are being laid out. Some say that it is only a question of time for the method to be introduced into existing villages, when the re-alignment of holdings and surface-drainage can simultaneously be put into force.

Besides increasing the yield of cotton and other crops, the provision of efficient surface-drainage is proving an important factor in removing the experimental error in variety trials and in other field tests. For some years it has been the custom to deal with the well-known experimental errors in field work by repeating the trials a number of times, and by subjecting the figures to mathematical treatment. The

[1] Howard, A. and Howard, G. L. C.—Drainage and Crop-production in India, *Agr. Jour. of India*, XIV, 1919, p. 377.

results of experiments, when carried out under such conditions, are not always visible to the eye but only emerge after the actual results have been freed from error. The defects of this method of testing varieties and new methods of agriculture in a country like India are obvious. As no very striking results can be detected by the eye, the work cannot posssibly appeal to the unlettered cultivator. The repetition of the plots, necessary to eliminate errors, introduces a number of practical difficulties in the lay-out, in sowing the plots and in harvesting and handling the crop. Unless the experimenter is a master of the mathematical principles and methods involved in the calculations, it is difficult for him to avoid a number of material fallacies while attempting to work out his results. In some respects, the conventional remedy for dealing with experimental errors in field work is almost as bad as the disease itself. One difficulty merely leads to another. The question arises: Is it possible, by improving the surface-drainage, to reduce the experimental error and to make the land yield more uniform crops? The results obtained during the last two years at Indore indicate that such a result is certain. A number of plots, on which at first the crops were exceedingly uneven, were taken in hand in 1927, and roughly graded. In a single year a marked improvement took place. Plot 1 is a good case in point. In the rains of 1927 this was sown with *san* (*Crotalaria juncea* L.). The height of the crop varied from 9 inches to 56 inches. During the cold weather of 1927-28, the plot was roughly graded and then sown with ground-nuts. The results show that the unevenness was very materially reduced. After the removal of the ground-nuts in October 1928, the grading of the plot has been improved and the surface-drainage perfected. It will be sown with cotton in 1929, and the uniformity or otherwise of the field will be determined. The results already obtained on a number of plots at Indore point to the supreme importance of correct grading and good surface-drainage on the black soils before any experimental work of any kind and before any variety trials are undertaken. There seems no doubt that soil-erosion and poor surface-drainage are very important factors in the production of irregular yields on these soils, and that the improvement of the drainage is the first step in dealing with the experimental error.

The Development of Soil Colloids during the Monsoon

The loss of the richest portion of the soil by erosion is only one of the consequences of the absence of a drainage system on the black soils. The excessive development of soil colloids, which is always observed

after the rains are well established, is equally detrimental. At the break of the monsoon and as long as the surface soil is capable of absorbing the rainfall, the tilth of the black soils leaves nothing to be desired. The soil is mellow, friable, and permeable. After about a third of the monsoon has been received, a notable change takes place. There is an excessive development of colloids, the soil becomes sticky, permeability slows down and then ceases altogether. The interference with soil-aeration and with nitrification which follows is at once reported by the plant. The growth of roots and shoots diminishes and then ceases, the foliage alters in colour, turns yellow and leaf-fall begins. This condition continues until a break in the rains allows the soil to dry when aeration and nitrification are resumed. The damage done is greater when the plants are small than when they are fully grown. Further, the effect is more pronounced on poor than on rich soil. The larger and more vigorous the plant, the greater is its power of resistance. Clearly, if this development of soil colloids could be regulated or prevented, percolation and aeration would be re-established, and the chemical processes in the soil would proceed in the direction of nitrate formation rather than in that of nitrate destruction. The plant would receive more food materials and there would be a corresponding increase in yield. Further, valuable time would be saved.

A critical study of the local conditions in Central India, combined with a knowledge of the factors known to be required for the development of colloids,[1] suggests the direction in which this problem can be attacked. We already know that the establishment of this adverse condition is retarded by the high content of organic matter in the heavily manured soils round villages and wells. The oxidation of this organic matter involves the continuous production of carbon dioxide, which tends to increase the acidity of the soil solution—a condition which helps to flocculate colloids. It is of course impossible to find the manure needed to raise and to maintain the organic matter content of all the black soil areas to a point approaching that of well-irrigated land. It may, however, be possible to add substances, in a finely divided state, to the soil before the rains which, after fermentation, will produce a steady stream of carbon dioxide or some weak acid. Among likely substances for this purpose, the two following have already been tried with promising results—safflower cake and *karanj*

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[1] Hall, A. D., and Morrison, G. G. T.—The Flocculation of Turbid Liquids by Salts, *Jour. of Agr. Sci.*, II, 1907, p. 244.

(*Pongamia glabra* Vent.) cake. These cakes have proved good substitutes for *rab* [1] in the treatment of rice nurseries in the Western Ghats and are known to produce better results on stiff soils than would be expected from their chemical composition. Of the two, safflower cake is the more effective for the probable reason that the finely divided husk ferments easily and so produces a slow stream of carbon dioxide. Other substances under investigation are powdered sulphur (which on oxidation produces sulphurous and sulphuric acid), powdered groundnut husk (which on oxidation produces carbon dioxide) and superphosphate (which on reversion acts as a weak acid and produces carbon dioxide).

The investigation of this adverse soil factor, which always develops during the rains after the surface soil is saturated, has only begun at Indore but the preliminary results obtained are full of promise for the future. If, as seems likely, the permeability of the soil can be regulated by appropriate manurial treatment, a great increase in the yield of cotton and of other crops will follow.

THE LOW CONTENT OF ORGANIC MATTER

The urgent need for more nitrifiable organic matter in the black soils is at once evident when we compare the growth of the cotton plant on the rich fields near a village with that on out-lying areas which, in Central India and Rajputana, are seldom or never manured. The addition of fermented organic matter leads to rapid growth, to larger plants, to a much higher yield of seed-cotton and to a crop which is able to withstand the heavy rainfall which so often checks the cotton plant on poor soils. No experiments are needed to demonstrate the effectiveness of more organic matter for cotton and other crops. No mathematical formulae and no replication of small plots are required to bring the results home to the people. This work has already been done, the whole country-side demonstrates the results. What is needed is to show the cultivators where to find the organic matter required and how to prepare it in the best way.

The broad lines on which the manurial problem of the black soils of India can be solved have already been worked out in China and Japan. All that is necessary is to convert every form of crop-residue and vegetable waste into finely-divided, fermented organic matter

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[1] Mann, H. H., Joshi, N. V., and Kanitkar, N. V.—The *Rab* System of Rice Cultivation in Western India, *Mem. of the Dept. of Agr. in India*, (*Chemical Series*), ii, 1912, p. 14.

according to the methods described by King in *Farmers of Forty Centuries*, London, 1927.

The statement constantly reiterated that the soil of India cannot be adequately manured, on account of the utilization of so much of the cow-dung for fuel, is only partially true. There is a vast mass of vegetable refuse which, if properly treated, will produce a large proportion of the organic matter and the combined nitrogen which the soils of India require. Most of this vegetable refuse is at present wasted or is mis-used. It is not uncommon to see dried leaves, stalks and other vegetable refuse burnt by the municipalities to save the expense of removal. Villagers often burn the refuse on the fields or at the best put it back into the land in an unfermented condition. It is a *distressing sight to see India's potential wealth going up in smoke and* moreover in ineffective smoke. The use of cow-dung as fuel for cooking has certain advantages, from the point of view of preparing food, but the misuse of vegetable refuse has none. Every scrap of vegetable refuse should be utilized as manure but it is useless to apply it to the soil in a raw state as is so often the case. The pore-spaces of the black soils need a constant supply of finely-divided, fermented organic matter, *ready* for nitrification, so that when the rains break no time is lost by the soil in preparing food materials for the crop. Time is perhaps the most important factor in the growth of monsoon crops on the black soils. Sowing must be carried out the moment there is sufficient moisture for the seed to germinate. The whole energies of the soil must then be used up in growing the crop. There must be no competition between the growth of the plant and the preparation of its food materials. Everything must be ready beforehand if maximum yields are to be obtained. Any delay is paid for by a greatly diminished yield.

The proper utilization of vegetable refuse is one of the most prominent features of the Institute and is carried out in a systematic manner. A regular compost factory has been laid out near the cattle shed and demonstrations are given to cultivators and to other visitors. The adoption of the methods in use at Indore will very greatly increase cotton production in Central India and Rajputana.

To prepare a supply of manure on Chinese principles, the various residues—, including such materials as cotton and *tur* (*Cajanus indicus* Spreng.) stalks, cane trash, weeds, leaves and every form of vegetable waste which is available—are broken up as finely as possible and are used as bedding for the work-cattle. In this way they absorb a certain amount

of urine and get mixed with some of the cattle-dung. A fine state of division is necessary, to allow the cellulose decomposing organisms full play, and also for copious aeration during fermentation. When work was started at Indore in 1924, one of the chief problems was the utilization of the cotton-stalks on account of the large area under this crop. It was found impossible to ferment the unbroken stalks, as the woody stems presented too few points of attack for the fungi and bacteria concerned in the breaking down of cellulose. It was found, however, that if cotton-stalks are first broken up they would readily decompose and yield excellent compost. At first the cotton stalks were reduced to the necessary state of division by the treading of work cattle on the threshing floor. Later, when large quantities of this material had to be dealt with, the work was done by means of a disc-harrow. A cheaper and more practical method has recently been suggested by Colonel E. H. Cole, C.B., C.M.G., the proprietor of the Coleyana Estate in the Punjab. The cotton-stalks are placed in a thin layer on the road between the cattle-shed and the well where the animals drink. The constant treading rapidly breaks up the cotton-stalks which, at the same time, become mixed with fine earth and a certain amount of cattle-dung. The preliminary experiments on the fermentation of crop residues, including cotton-stalks, were carried out at Indore in 1925 and 1926, and the results were published in the *Agricultural Journal of India* (XX, 1925, p. 395 and XXI, 1926, p. 485). In a recent paper, Dr. Youngman[1] has given his experience which agrees with our results.

Besides a supply of vegetable waste in a proper state of division, a supply of some nitrogenous substance, which acts as a nitrogen starter for the organisms, is essential. At Indore the nitrogen starter is provided by the urine absorbed by the bedding, by the cattle dung and by the manurial earth from the floor of the cattle shed. This latter is removed and replaced by fresh earth every two months. A base for neutralizing acidity is obtained by the use of ordinary soil and by wood ashes when available. The fermentation is carried out in pits, each 30′ × 14′ × 2½′ deep, with sloping sides. The depth of the pits is an important factor as it affects both the air and the water supply. After several years' experience, 30 inches has been found to be the best depth. At Indore the pits are connected with a water supply. The cultivator would have to make arrangements to get water from his

[1] Youngman, W.—Musings in a Monsoon Climate, *Empire Cotton Growing Review*, VI, 1929, p. 35.

well. The bedding after use is mixed with the cow-dung and earth in the following proportions: bedding, 20 baskets; earth, including manurial earth and wood ashes, 2 baskets. A basket of old compost is sprinkled over the daily charge to inoculate the mass with the organisms needed. The pits are filled evenly and watering is begun at once. Fermentation is rapid and the temperature rises considerably. When labour is available, it is a good thing to turn the heap once. In about three to four months, the mass is converted into finely divided organic matter, resembling old leaf-mould. During the rains, when the pits are liable to become water-logged, the manufacture of compost is best carried out in heaps on the surface between tho pairs of pits. In the cold season and in the hot weather, however, pits are necessary to retain sufficient moisture for fermentation. The nitrogen content of the final product is well above that of good farmyard-manure. During 1928, nearly 700 cart-loads of Chinese compost were prepared at Indore from the waste vegetable products of the leased area. It is expected, when the whole of the land comes under crop, that at least 1000 cart-loads of this valuable manure will be produced every year. This will mean that every acre of the experimental area will receive at least ten cart-loads of compost once every three years. This dressing is rapidly raising the fertility of the area. The work on compost-making was started early in 1925, and this is now the fifth year of manufacture. An interesting point is now arising. At the beginning, the greatest difficulty was found in collecting sufficient vegetable refuse. Now the problem is to use up the available supply fast enough. The increased fertility, due to the annual application of compost, is increasing the growth of the crops. More and more composting material is therefore being produced. This in turn produces a still better crop. Incidentally, this experience answers the statements, often brought forward in India, that the growing of an improved variety is disadvantageous owing to the soil exhaustion involved.

The compost factory at Indore adjoins the cattle shed and consists of thirty three pits, each capable of holding 20 to 25 cart-loads of finished compost (Plate VII). This manure factory, in which the Indian ox is one of the essential factors and in which indigenous materials only are employed, now attracts many visitors.

A further step in increasing the nitrogen supply on the cotton growing areas is the improvement of the cotton-*juar* rotation, now unfortunately so common as a result of the recent high prices of raw cotton. A rapidly growing monsoon pulse is one of the great needs of

the moment in Central India. Fortunately this is available in the shape of the Spanish pea-nut, the area under which is rapidly increasing in Gujarat, Khandesh, and in the adjoining areas of the Central Provinces. This variety of ground-nut is a rapid grower, is easily harvested and possesses a seed rich in oil. In years when the late rains are favourable, it is possible to harvest the ground-nuts in time for a cold weather crop of wheat or gram. Trials made at the Institute in 1927 showed that this variety does well in Central India. Seed-distribution is now in progress and it is hoped to establish the crop all over Central India as a rotation crop for cotton. It will then, by improving the nitrogen supply, help to increase the yield of seed-cotton.

Some time must elapse before a simple remedy can be suggested for the removal of the third limiting factor namely, the formation of colloids, but the removal of the other three—*kans*, water-logging and the low content of organic matter—is only a matter of propaganda and time. The investigations of the last few years show that the fertility of the black soils of India can be doubled by methods well within the means of the cultivator. Not only will this increase the amount of cotton produced but the removal of the water-logging factor should improve both the quality and uniformity of the product. Every effort will be made, by demonstration and publicity, to interest the rural development departments of the various States of Central India and Rajputana in these improvements.

CHAPTER V

SOME FURTHER AGRICULTURAL IMPROVEMENTS

In addition to the investigations which are being carried out on the agronomy of cotton, some attention has been paid to the improvement of well-irrigation, to the cattle problems of Central India and Rajputana and to the introduction of simple implements and machines. These matters form the subject of the present chapter.

IMPROVEMENTS IN WELL-IRRIGATION

The importance of irrigation to the Central India and Rajputana States is at once evident when the land revenue of the fields, commanded by wells, is compared with that levied on the un-irrigated areas. In the Indore District of the Holkar State for example, the average revenue of well-irrigated land is over Rs. 10 an acre, on dry land the average assessment is just above Rs. 2-8-0. In the past, the wells have been utilized very largely for the production of opium, a crop which does not require water after the beginning of the hot weather. Almost any well therefore could be made use of for the poppy crop. Now that the production of opium is being given up, two things are necessary for maintaining and developing well-irrigation: (1) the existing shallow wells must be deepened and made permanent so that the water supply can be improved, and (2) valuable substitute crops like sugar-cane, cotton and wheat must be introduced to take the place of opium. Once the wells are improved and their number increased, a suitable opening for the investment of local capital in land improvement will become available.

Great scope for the development of irrigation exists in Malwa, where extensive subterranean water-bearing areas occur as folds in the strata. These regions are delimited by the general character of the vegetation, by the way the trees develop new foliage in the hot weather and particularly by the occurrence and growth of the wild date (*Phœnix sylvestris* Roxb.). This monocotyledon produces surface roots (which function in the rains only) from which branches grow vertically downwards to the level of permanent water. The roots of the wild date behave in Central India very much like those of the trees of the Indo-

Gangetic plain.[1] Areas therefore, in which this palm flourishes in the hot season, are those in which wells can be dug with certainty. Nature has provided Central India with a most useful water-diviner.

The improvement of existing wells. A number of the existing wells in Malwa are little more than large holes in the ground, which supply sufficient water for the opium poppy and then dry up. After cleaning and deepening, these wells require a masonry course, extending from the rock to at least a foot above the surface of the ground. In many cases the water supply might be greatly improved by drilling through the underlying layer of rock to the next inter-trappean, water-bearing stratum below.

When an efficient well has been constructed, its proper preservation is a matter of great importance. It is a common experience on the black soils for a well to fall off in efficiency, especially if it is frequently emptied in the course of irrigation. This has been found to be due to the exposure of the inter-trappean layers to the atmosphere.[2] Frequent exposure of the partly decayed rock (in which the springs which feed the well occur) leads to rapid disintegration in the direction of soil formation, and to the production of colloids, which seal up the crevices in the rock and cut off the flow of water. This can only be renewed by the enlargement of the well. In all wells in the trap areas, the springs which feed the well must never be uncovered but must be protected by a permanent water-seal. To accomplish this, two iron bars should be fixed across the well, at a point about two feet above the springs. As soon as the *mhots*[3] reach the cross-bars, further irrigation is only possible after the well fills up again. In the case of wells worked by centrifugal or other pumps, the foot-valve must be placed at a suitable distance *above* the springs so as to prevent the well being emptied.

While it is an obvious advantage to make as much use as possible of the troughs of underground water in Malwa, nevertheless care must be taken not to sink any unnecessary wells and so overtax the local supply. Some interesting information on this subject has been obtained at the Institute during the last four years. The leased area is 300 acres in extent and at present is provided with six wells. A continuous

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[1] Howard, A.—The Effect of Grass on Trees, *Proc. Roy. Soc.* B, Vol. 97, 1925, p. 284.

[2] Howard, A. and Hyde, H. A.—The Cotton-growing Problems of the Black Soils of India, *Agr. Jour. of India*, XXI, 1926, p. 318.

record of the water levels of these wells has been kept since 1925. Three of the six wells have been in constant use for irrigation purposes. The results show that three of the wells in Blocks B and C tap the same underground source while the other three are independent. Thus in an area of 300 areas, there are at least four independent sources of ground-water. When the development of well-irrigation is taken up on modern lines in Malwa, it will not be a difficult matter to test the wells in a locality and to ascertain whether pumping affects those in the vicinity, and so decide whether or not it will pay to sink any more.

Perhaps the most important step, in improving the existing wells, will be to impound as much of the monsoon run-off as possible in suitable areas, by means of small embankments properly constructed. These minor reservoirs should first of all be made in the neighbourhood of well-irrigated villages, so that the existing wells can be maintained at a high level during the hot weather and large areas of valuable crops like sugar-cane and cotton cultivated. At the moment, the storage of surplus monsoon water is largely left to chance. There is no reason why this should continue and why the scientific control of the monsoon should not be extended to include, not only surface-drainage and the grading of the fields, but also the storage and utilization of the run-off.

Defects in the present methods of watering. The defects in the present methods of well-irrigation in Central India and Rajputana are many and obvious. These are as follows :—

(*a*) There is a considerable loss of water in the well itself before the irrigation channel is reached. *Mhots* are often defective and *thalas* are not always properly made. An appreciable quantity of water is lifted to the top of the well and is then allowed to fall back again. In some cases, power is wasted by lifting the water higher than is necessary.

(*b*) The main channels leading to the fields are often only temporary affairs, leaky and liable to burst.

(*c*) The amount of water at present used in irrigation is excessive—far more than the crops require. A good deal of labour is also wasted in its application.

(*d*) Inter-culture after irrigation is the exception rather than the rule.

(*e*) The surface of well-irrigated lands is not properly graded. This leads to water-logging in the rains, to the loss of large quantities of valuable nitrates and to greatly diminished crops.

While in charge of the Fruit Experiment Station at Quetta from 1910 to 1918, some attention was paid to irrigation, the results of which

have already been published.[1] As most of this work applies, with slight modifications, to the black soils, the improvement of well-irrigation at Indore was at once taken in hand. Two model well-irrigated areas—plots 32 and 38 (Plates X and XI)—were laid out. The improvements which are to be seen at the Institute are these:—

(*a*) The water is led to the fields without loss in strong, well-made channels with wide berms which serve as foot-paths. These are lined with tiles up to the point where actual irrigation commences, the cost of these lined channels being added to that of making the well.

(*b*) The surface to be irrigated is graded so that it is flat in one direction and there is a fall of not less than three inches in every hundred feet from the irrigation channel to the drain. The plots to be watered are divided into long beds (*kiaris*) from eight to ten feet wide and irrigated from one end. Each irrigation channel serves two plots and there is a drain for carrying off the monsoon run-off between every

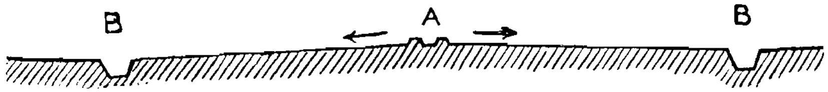


FIG. 7—Irrigation and drainage
A, irrigation channel. B, drain.

two plots. The arrangement will be clear from Fig. 7. Once land is prepared for irrigation and surface-drainage, no further grading is required, provided care is taken not to disturb the levels by the use of soil-inverting ploughs.

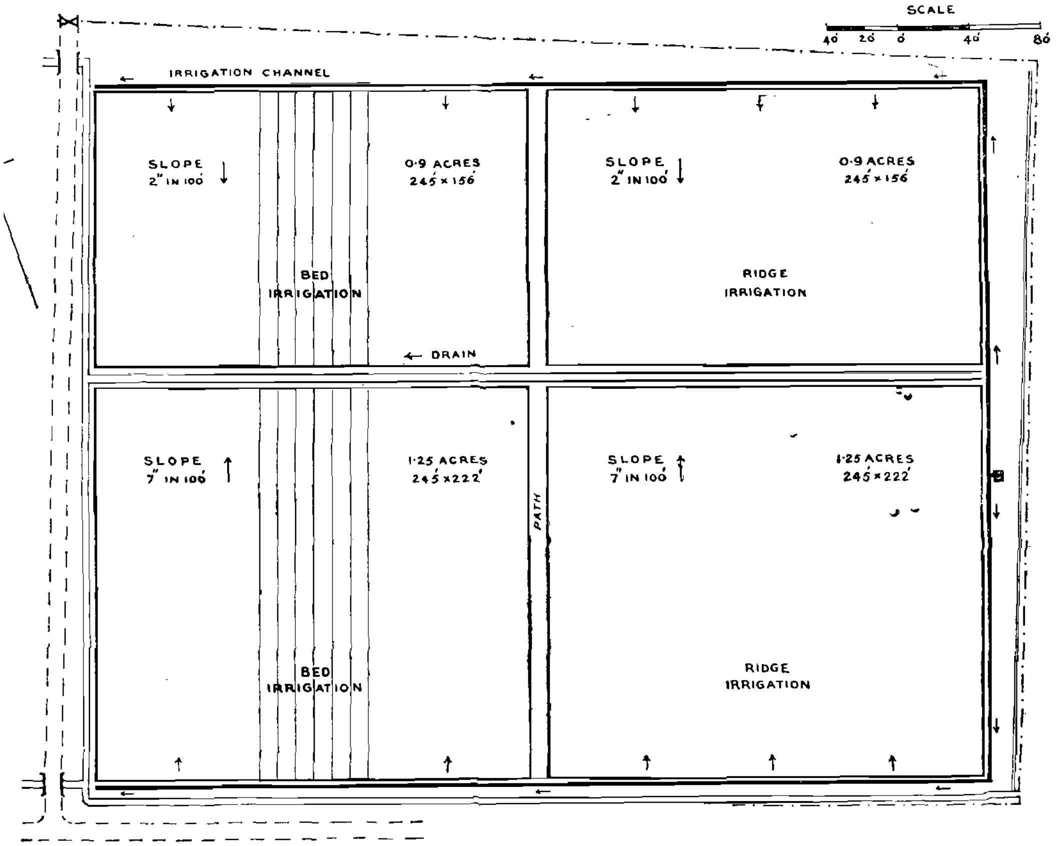
(*c*) The use of the long irrigation bed (*kiari*) enables irrigated crops to be sown in lines, and interculture to be carried out after each irrigation.

(*d*) The correct grading of the surface facilitates ridge-cultivation, in which the irrigation water is applied in the furrow between each pair of ridges. In this way the roots of the plants on the ridges obtain abundant air while inter-culture by means of a Plant Junior hand-hoe is easy after each watering. Preliminary results, obtained in 1928, suggest that this method might be used with advantage for irrigated cotton.

Substitute crops for opium. Once the wells of Central India and Rajputana are put in order, attention will have to be paid to the

[1] Howard, A.—The Irrigation of Alluvial Soils, *Agr. Jour. of India*, XII, 1917, p. 105.

IRRIGATION EXPERIMENT (PLOT 32)



establishment of substitute crops for the opium poppy. Up to the present, results have been obtained at Indore on two possible substitute crops—sugar-cane and wheat. The experiments with cotton are still in progress.

The results obtained with sugar-cane are of the greatest promise. On properly graded land, a crop of S48 sugar-cane, grown on the Java system (Plate XII) has yielded 35 tons of stripped cane to the acre from which samples of *gur* of excellent quality have been made. The demand for setts of this variety has hitherto been so great that it has not been possible to convert an acre into *gur* and to sell the produce in the local market. This will be done during the present year. The amount of water and manure required to raise such large crops is surprisingly small. Watering once a month, followed by the earthing up of the canes, is all that is needed during the hot weather. Thirty cart-loads of Chinese compost to the acre supply all the nitrogen that is needed. The results obtained at the Institute and on the fields of the cultivators suggest that a yield of at least 100 maunds of *gur* to the acre is possible under Central Indian conditions, using the water and manure now at the disposal of an industrious and well-to-do cultivator. A local market for the produce already exists at Indore and other large towns in Malwa.

In the case of wheat, the results are equally promising. When improved bread wheats—Pusa 4, Pusa 12 and Pusa 52—were grown on graded land at Indore in 1927-28, a yield of over 30 maunds of high quality grain to the acre was obtained with two irrigations. These results were secured the first year after levelling, with only moderate dressings of compost and with the minimum of irrigation water. When the fields have settled down and the content of organic matter has been raised, still more striking results are to be expected. Yields of over 40 maunds of grain to the acre are by no means impossible on the black soils.

The Improvement of Cattle

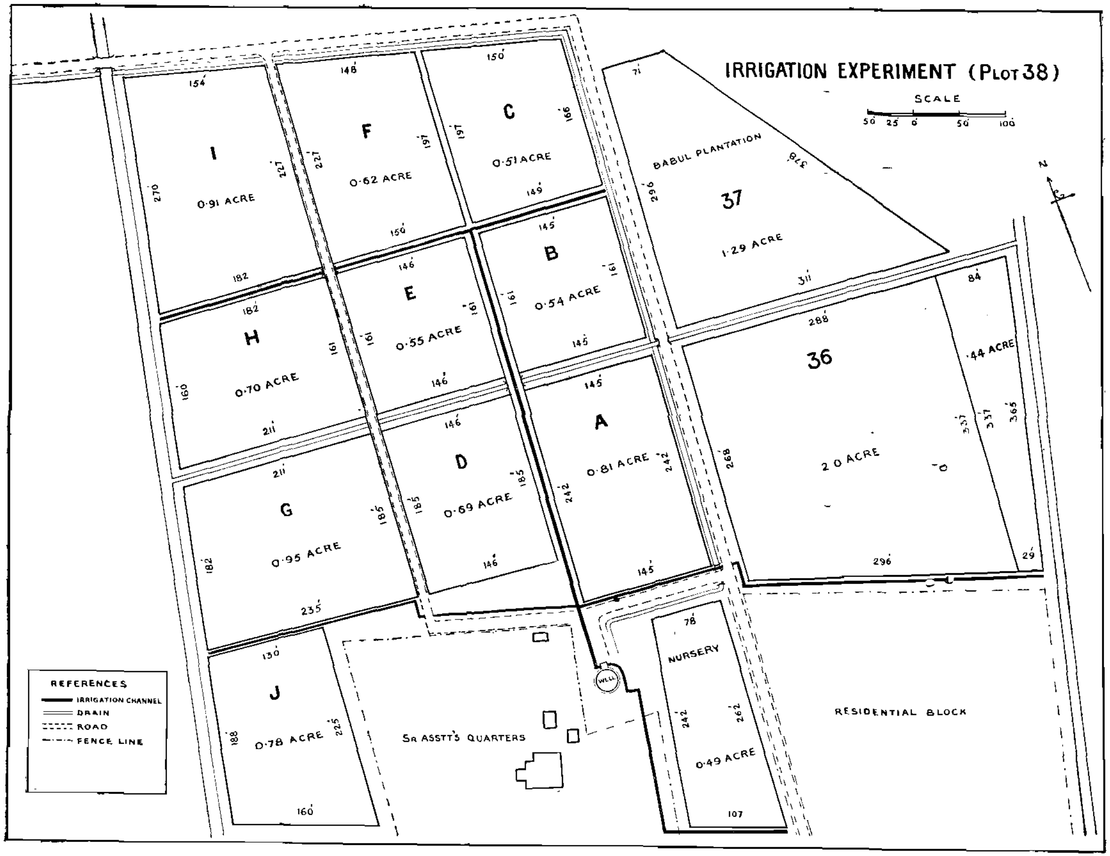
Young work cattle form one of the agricultural exports of Central India and Rajputana. After the rains and during the cold weather, the roads are often encumbered with large droves of young stock on their way to the cotton fields of Khandesh and Berar. In many cases, these animals are of a good type but rather on the small side for making the best working oxen. An obvious improvement would be to show the local stock raisers how to keep these young animals for another year in Central India, and so export a larger and better type. If this could be done and if the present trade could be partly deflected to the United Provinces and

Bihar, where cattle of the Central India class are in great demand at good prices, the stock raising areas of Central India and Rajputana would greatly benefit.

The difficulty in the way of this obvious improvement is the lack of suitable fodder during the hot weather. There is ample grazing during and after the rains. The stock raising tracts produce large quantities of dry grass of good quality, a good deal of which is exported. The problem is to feed the cows and the young stock properly during the four months, March to June. A similar difficulty had to be overcome in the case of the Institute work-cattle. At first the animals had to be fed during the hot months on quite unsuitable food—wheat straw, dried grass and millet stalks with a small ration of crushed cotton seed. On this diet it was impossible to keep working animals in proper condition and in good health. For the first time in our twenty-five years' experience in India, we had to deal with a mild attack of foot and mouth disease and similar troubles. The unsatisfactory condition of the work cattle, during 1925 and the hot weather of 1926, forced us to study the question of improving the fodder supply of our cattle force.

The first attempts to make silage from *juar* were carried out in the autumn of 1926, when a plot of lucerne was also started. In 1927, and 1928, the details of the manufacture of silage from *juar* were perfected and the growing of lucerne was placed on a satisfactory basis. These simple and obvious improvements in the food supply of the hot months have worked wonders. The animals are now in first class condition during the hot weather; the heavy work connected with the sowing and inter-culture of the monsoon crops is carried out at the maximum speed and most interesting of all—foot and mouth disease and other ailments have disappeared. The work cattle of the Institute, which had to be kept in the background during 1925 and 1926, can now be shown to visitors and can be exhibited at agricultural shows as type specimens of the Malvi breed. If a herd of adult animals can be transformed in two years by improved feeding, still more striking results are to be expected in the case of cows and young growing animals.

In 1928, a beginning was made in getting the cultivators to convert a portion of their *juar* crop into silage by the methods in vogue at the Institute. The results have been most successful and steps are being taken to provide the Department of Rural Development of the Holkar State and the new Agricultural Department of Jaipur with a portable silage making set, suitable for use on the main loads leading to the capital. The machinery consists of a portable 5 H.P. oil engine and a small


IRRIGATION EXPERIMENT (PLOT 38)
SCALE
50 25 0 50 100
N
I
0·91 ACRE
F
0·62 ACRE
C
0·51 ACRE
H
0·70 ACRE
E
0·55 ACRE
B
0·54 ACRE
G
0·95 ACRE
D
0·69 ACRE
A
0·81 ACRE
J
0·78 ACRE
BABUL PLANTATION
37
1·29 ACRE
36
2·0 ACRE
·44 ACRE
NURSERY
0·49 ACRE
WELL
SR ASSTT'S QUARTERS
RESIDENTIAL BLOCK
REFERENCES
IRRIGATION CHANNEL
DRAIN
ROAD
FENCE LINE

portable fodder cutter. The pits are designed so that they can be filled and covered in during one working day—an important detail if *juar* is to be converted into silage with the minimum loss of edible fodder. As soon as the manufacture of silage has been firmly welded into the rural economy, steps will be taken to show the people how to produce lucerne for their animals and so provide a small quantity of fresh green food for the four hot months. Side by side with the preparation of silage, the manufacture of compost from the leaves of forest trees and from other vegetable wastes will be introduced into the local agriculture, so that the *juar* needed for silage can be provided without any interference with ordinary cropping. For every pair of working oxen, at least one acre of good *juar* should be converted into silage every autumn. To raise this a dressing of about ten carts of compost is needed. To bring about this revolution in the feeding of the cattle, no large amount of capital is required. The compost can be prepared from vegetable wastes: a suitable *juar* crop results from a moderate dressing of compost; the machinery needed for the manufacture of silage can either be hired by the day or operated by a strong co-operative society.

The Sale of Implements and Machines

In order to speed up the current work of the Institute and to provide as useful an object lesson as possible for visiting cultivators and *zamindars*, a good deal of attention has been paid to the choice of implements and machines. The result has been a growing demand from the public for some of these appliances. These are now purchased in bulk and retailed to applicants. During the last two years, a number of simple pumping sets (consisting of a 5 H.P. portable oil engine and a centrifugal pump), bullock gears for utilizing cattle power, chaff cutters for the preparation of silage, small mills for crushing cotton and other seeds for the work cattle, American levellers for grading land, *kans* eradicating ploughs, improved country drills for sowing cotton, wheat and ground-nuts have been sold. Orders are now being received for the wheels, axles and springs of the Canadian fruit lorries in use at the Institute. When work began in 1925, a supply of suitable implements was purchased for our own use. No one on the staff foresaw the local demand which has since arisen for our appliances. That it has taken place so quickly is a striking proof of the need of a central Institute for the Central India and Rajputana States and of the readiness of the best *zamindars* to take up simple and practical improvements.

One difficulty in the purchase and supply of implements and

machines has had to be overcome. At first this was financed by means of the ordinary budget, and the receipts were credited as income. This however soon led to difficulties, as an ordinary budget is not designed for trading. The difficulty was got over by starting a separate trading account for the purchase of all articles sold to the public and into which all sale proceeds are paid. This has proved of the greatest use. The trading activities of the Institute now go on smoothly without interfering with the ordinary work of the experiment station, which is financed from the annual budget and which can now be drawn up in advance with a reasonable degree of accuracy. As time goes on, the local influence of the Institute can be accurately gauged by the annual turn-over of the trading account. If the figure is a large one, the usefulness of the institution will need no argument. At all new research institutes, provision should be made from the very beginning for trading, which should be financed by a special trading account, quite distinct from capital expenditure and from the annual budget. If this is not done, all kinds of financial difficulties arise. Moreover, the assistance given to the public is certain to be curtailed if every service of this character leads to an accounts objection.

PLATE XII

IMPROVED SUGAR-CANE GROWN ON THE JAVA SYSTEM AT INDORE

CHAPTER VI

THE MAINTENANCE OF LIAISON BETWEEN THE INSTITUTE AND ITS SUPPORTERS

As soon as the Institute was brought into working order and a number of practical results were obtained, steps were taken to build up an effective liaison with the subscribers. This side of the work will naturally develop with the progress of the scheme.

Training. Perhaps the most effective method of establishing liaison between any institution and its supporters is by means of its students and the general training it provides. Although it is only a little more than four years since the leased area was taken over, a good beginning has been made in the training of post-graduate students nominated by the Central Cotton Committee, of officers and students sent by the Contributing States and of selected cultivators.

In order to obtain a supply of trained men for work on cotton, the Central Cotton Committee established some years ago a number of research studentships of the value of Rs. 150 per mensem for two years, open to science graduates of the Indian Universities. At the time of writing (June 1929), nine of these post-graduate students have completed their training at Indore. Of these, seven have been provided with suitable appointments—six in the various Agricultural Departments and one in the Lac Research Institute at Ranchi. At the moment, two are unemployed but it is expected that they will shortly receive suitable posts.

The Contributing States are now sending an increasing number of officers and students for training. Four of these officers have completed their course and five are now under instruction. A number of others are due to join before the rains. The Holkar State has arranged to pass the whole staff of the *amins* (*tehsildars*)—thirty-three in number—through the Institute and to give them a month's course during the early monsoon. This special course was started in 1928 with five officers and will be continued till the whole of the establishment has been dealt with. Its general aim is to stimulate interest in the development of the country-side rather than to teach the principles of agricultural science. By means of these short courses, the Revenue Department of the State will be brought into close touch with the Insti-

tute and will help in making the results known to the villagers. During 1928, nine sets of furnished quarters were provided on the estate for the use of officers sent by the Contributing States, so that the men can reside on the spot and devote their whole time and energy to following the work in progress. Five of these furnished quarters, known as the Holkar State block, were provided by the Indore State at a cost of Rs. 9,298; four were erected from the funds of the Institute. These quarters are constantly occupied and are greatly appreciated by the men who live in them.

For making practical use of the results already obtained, the most urgent need at the moment is a supply of trained men suitable for employment as agricultural officers in the larger States. Two of the Rajputana States--Jaipur and Bikaner--have already been provided with officers who received their training at Indore. To meet the existing demand from the other States and to provide for the future, two additional training posts of the value of Rs. 100 per mensem have been added to the establishment. In addition, the Irwin studentship for the agronomy of cotton has been founded by one of the merchant princes of India--Sir Sarupchandji Hukamchand of Indore--to commemorate the visit of H.E. Lord Irwin to the Institute on July 29th, 1928. This is an all-India studentship and is now being competed for by the most distinguished science graduates of the Indian Universities. These three training posts will be of the greatest use in providing a steady stream of trained men for the States of Central India and Rajputana. A fourth training post for plant-breeding is urgently required and it is hoped that some donor, interested in the development of Central India and Rajputana, will come forward and found a post for this work.

Besides a supply of agricultural officers, men who cultivate their own land on improved lines will be needed in large numbers for the work of rural re-construction. H.H. the Nawab of Jaora in 1928, took the first step in providing for the training of the type of man required. In that year, His Highness decided to endow a Glancy Scholarship of the value of Rs. 30 per mensem, tenable at the Institute for the training of the sons of cultivators from the Contributing States who will afterwards farm their own land.

For introducing improvements in the villages themselves, it will be a great advantage if a number of trained cultivators can be placed at the disposal of the agricultural officers in the various States. To provide for this, it has been decided to make use of the labour force of the Institute as a training ground and to export every year a number of

trained workmen. Four of these men have already been sent to Jaipur and Bikaner, where they are doing good work. Some of the other States are beginning to send selected cultivators for training for whom a block of six quarters has already been provided. The great need at the moment is a steady stream of promising young cultivators, who can be trained for at least one year, who can pass through the various sections of the Institute and then become available for service in the States. As a beginning in this work, it has been arranged for a number of boys from the Malwa Bhil Corps lines to be trained as ploughmen and then to take up cultivation in the villages from which the corps is recruited.

Indian Central Cotton Committee. An important step has just been taken which will enable the Institute to keep in closer touch with the Central Cotton Committee (its chief subscriber) than is possible by means of printed reports and occasional visits from its members. Once every three years, beginning in December 1929, the full Cotton Committee will hold its cold weather meeting in the library of the Institute and in this way all the members will be brought into touch with the work in progress. Contact between the cotton growing States of Central India and Rajputana and the Central Cotton Committee has been established by the appointment of the Director of the Institute as the representative of these States on the Central Cotton Committee. This arrangement also helps to keep the Institute in touch with the Secretary of the Central Cotton Committee and with the Director of the Technological Research Institute at Matunga.

The Governing Body of the Institute. As a rule, the Board of Governors of the Institute meets once a year. These meetings are now held at the Institute and are well attended. After each meeting, a visit is paid to the various sections. In this way the officers of the Central Cotton Committee (the President, Vice-President and Secretary) are able to follow the work in detail and also have opportunities of meeting the President and the representatives of the Contributing States.

Cultivators' Meetings. One of the methods adopted in India, for awakening the interest of the actual cultivator in agricultural improvements, is by means of agricultural shows, of which the well-organized exhibitions held during recent years at Allahabad, Nagpur, Poona, and Ahmedabad are among the largest and most important. While these shows are of great value to the Agricultural Department, to Government and to the intelligentsia of the country and do a large amount of good, nevertheless they are apt to bewilder the ordinary villager.

Moreover, their cost in actual money and in the time and energy of the officers of the Agricultural Departments (on whom falls the burden of organization) is considerable. When the progress made at Indore was such that a number of practical improvements were ready for the ordinary villager to see, the question of the best way of bringing the cultivator and the results together had to be considered. In place of the expensive and time-consuming agricultural show, something cheaper and simpler had to be devised. At the suggestion of Khan Bahadur Aziz-ud-Din Ahmed, C.I.E., Diwan of Datia, selected villagers were collected from the States and were shown the various improvements in operation at the Institute without the distractions and amusements of an ordinary agricultural exhibition. The first annual cultivators' meeting was held on January 27th and 28th, 1928, when groups of cultivators, about 200 in all, in charge of suitable officers, were sent by the following States: Indore, Datia, Dhar, Jaora, Ratlam, Barwani, Bijawar, Sitamau, Narsinghgarh, Tonk and Jhalawar. The cultivators were housed in two *serais*—one lent by the Holkar State, the other by Sir Sarupchandji Hukamchand. They were transported to and from the Institute daily in motor lorries, placed at the disposal of the Institute free of charge by the Holkar State and by the Malwa United Mills. Twelve demonstrations were given, six on each day, on the following subjects:—

A. CULTIVATION

1. The eradication of *kans* and *kunda*.
2. Soil-erosion and surface-drainage.
3. The Gujarati seed drill.

B. WELL-IRRIGATION

4. The improvement of sugar-cane.
5. The crushing of sugar-cane.
6. A new water-lift.

C. CROPS

7. Ground-nuts, a rotation crop for cotton.

D. MANURES

8. The preparation of compost.
9. The use of *karanj* cake as manure for cotton.

E. Cattle Food

10. The preparation of cotton seed for work cattle and buffaloes.
11. The poor man's engine.
12. The introduction of silage.

The meeting was a great success and was much appreciated. It will be repeated on a larger scale in December of the present year and made an annual feature of the work of the Institute. During the afternoons, conferences with the State officers connected with extension work in the villages will be held and the opportunity will be taken to place them in touch with the general work of the Central Cotton Committee. In the future, these meetings will be of the greatest use in the establishment of an improved type of cotton in Central India and Rajputana.

Visitors to the Institute. The first cultivators' meeting produced other results besides interesting a number of State officers and villagers in agricultural improvements. The general public, for the first time, began to understand the purpose of the Institute and to realize its great possibilities. Since the meeting took place in January 1928, there has been a growing stream of visitors, many of whom are either local notables or well-to-do men who are beginning to take up the improvement of their land. Actual cultivators from the villages are now coming in larger numbers, many of whom work for a time to learn new methods. At present the visitors are shown round either by the Director or by a member of the staff. It will, however, be necessary before very long to appoint a special member of the staff for this work so that this duty can be carried out effectively, without any interference with the current work of the Institute. The stream of visitors has led to an interesting development. Many of them are shown the large reference library, which includes a few reference books on agriculture which are lent to the staff, students and State officers. A demand has now arisen for sale copies of many of these books, so that it has been necessary to add a book-shelf to the library at which standard books in English, Hindi and Urdu, as well as periodicals can be purchased.

Developments in the Contributing States. The results obtained at the Institute are producing their inevitable effects in the Contributing States. In almost every State, definite progress can be recorded, the particular direction depending on local needs and resources.

In the Holkar State, a new departure has been made in the direction of the mobilization of the resources of the Darbar for the re-

construction of the country-side. The Co-operative and Agricultural Departments have been amalgamated into a new Department of Rural Development in charge of a Commissioner. By this means, the Co-operative Credit movement is being utilized to carry out a definite programme of improvements in the villages and not merely to free the cultivators from debt. The new Development Department works in the closest touch with the Institute, and is now opening a farm of its own for the improvement of the Malvi breed of cattle at Balda near Simrole. It also helps in the production and distribution of the new monthly agricultural vernacular journal—the *Kisan*—which is subsidized by the Holkar State and assisted by the Institute. Close touch is also maintained between the Department of Rural Development and the officers connected with revenue, rural education, and rural sanitation.

In the other States of Central India and Rajputana, no less interesting developments are taking place. A new experimental farm is being started by H.H. the Maharajah of Bikaner on the new Gang Canal, for dealing with the local problems presented in the best use of the available supply of canal water. In Jaipur, a large cattle and demonstration farm is being started at Basi and work among the cultivators is in progress. In two of the Central India States, agricultural schools are being opened in connexion with the new demonstration farms, a feature which is likely to spread. In all cases where demonstration farms are being started or work in the villages is being undertaken, the State officers in charge of the work are sent to the Institute for a definite period of training, so that they can thoroughly understand the work they have to do among the people. From more than one State, selected cultivators are receiving instruction. In all cases the advice of the Institute is sought before any schemes are undertaken and in this way a good deal of money has been saved in the preparation of new projects. The original idea, that the Institute would serve as a centre of agricultural research and of agricultural information in Central India and Rajputana, has already been realized. More and more interest is being taken by the Darbars in the work, and more and more advantage is being taken of the results. It is now generally recognized that the Institute has become an important research and training centre, which exports ideas and information on rural reconstruction as well as improved varieties of crops and new methods of cultivation. It is already acting as a stimulus in general rural development. The States have realized the advantage of possessing an up-to-date experiment station in their midst, so that their resources can be utilized on definite and

practical local schemes. In this there is great economy, in time as well as in money. In a single generation it is more than probable that some at least of the Contributing States will re-construct their villages, and incidentally double their land revenue.

CHAPTER VII

THE ORGANIZATION OF AGRICULTURAL RESEARCH

One of the problems of the moment, in the organization of agricultural research in India and other parts of the Empire, concerns the possible division of the work between the local and the central institute. For the last twenty-five years, attempts have been made in this country to find the ideal solution by sharing the burden of agricultural research between the Government of India and the various Provincial Governments. The Government of India at present maintains three experiment stations: Pusa (Agricultural Science), Muktesar (Veterinary Science) and Bangalore (Animal Husbandry and Dairying) and, in addition, a small cane-breeding station at Coimbatore in South India. These institutions are expected to devote their attention to scientific research of a more or less fundamental character, and are not directly concerned with the work in the villages. The Provincial Departments of Agriculture are also provided with research stations and with large staffs for work in the districts. A somewhat similar system is being adopted in the non-self-governing colonies and in some of the dominions overseas. A chain of imperial research stations, for dealing with fundamental questions, is being set up, as funds and staff permit, in East Africa (Amani), Ceylon, Malaya, Queensland and West Africa, in all of which local Departments of Agriculture already exist. The question arises: Is this system the ideal one and are two kinds of research stations necessary? Is the problem based on the merits of the case or does it arise from accidents of administration or from failure to realize what successful research work in agriculture entails in the way of staff and facilities? In many cases, the existence of the central institute is undoubtedly due to the feeling that the supreme government should not confine itself to the collection of revenue and to administration pure and simple, but should contribute something to the development of the country. In other cases, the foundation of the central institute originates in the disappointment experienced by the administration and by the general public at the meagre results obtained by some local agricultural department (often poorly staffed and equipped). It is not always realized that instead of founding a new institute, the assistance given by the Central Government might either take the form of grants-in-aid (as in Great Britain) or,

when a well-equipped central institute has been founded, the local research work might be discontinued altogether.

On the relations between the central and the local research stations, the literature is neither extensive nor definite. The need for central stations is more or less taken for granted. If, however, two kinds of research stations are required, it should not be a difficult matter to establish, from first principles, a case for their existence and to define their functions. It is on this question of the definition of functions that the greatest difficulty is experienced. Various terms, such as fundamental, long-range and wide-range research, have been coined to describe the work of the central institute, but very little has been done to give a precise meaning to these phrases and to explain why this work cannot be carried out at any experiment station, properly staffed and equipped.

Difficulties are certain to arise in the purpose and conduct of the stations which devote themselves to long-range and wide-range research. Once these are established and begin work, their functions have to be defined and kept separate from those of the local Agricultural Department. The central station is expected to devote itself to fundamental questions. As long as its activities are confined to furnishing a scientific explanation of well-known practices, no clash with the local Department of Agriculture is likely to occur. Such work corresponds with that carried out in the great republics of learning—the universities—in the shelter of which the investigators work in peace. In a central experiment station, maintained by public funds, the working conditions are very different from those in a university. Adequate protection for the workers is impossible under a system of finance, which frequently has to be justified by results of value to the country which furnishes the money. Sooner or later, the central station will have to show economic results or close down. The production of practical results solves one problem but simultaneously creates another. The moment the researches of the central station result in such things as the production of new varieties suitable for large areas of country; of improved methods of agriculture; of new and better implements, and so forth, the station finds itself in the position of a factory, turning out finished articles, without a market. It can only dispose of its products by means of the local Agricultural Department, which is likely to possess similar goods of its own for disposal. Putting aside the question of duplication of effort, it requires no argument to prove that a situation of this kind is not without its difficulties, and that

the marketing of the products of the central station will need some very delicate adjustments. This is not the only drawback. The attempt to divide research into two classes—fundamental and local—imposes limitations on both the groups of workers involved, and seeks to maintain a distinction without any real difference. Instead of being allowed to work out their own salvation, and to follow the gleam untramelled in whatever direction it may lead, both sets of workers must either conform to the organization or come in conflict with it. In the former case, their work, on account of its limitations, may lead to nothing. In the latter, they may solve their problems at the expense of their own interests. Clearly such an organization does not fit the work. It erects walls where, from the nature of the case, the rule should be—no walls. There is so much to do in agricultural research in the Empire and the workers are so few that everything must be done to prevent the different sections of the organization from wearing themselves away through internal friction.

It has been suggested that a solution of some of these difficulties might be found if the central institute were given a small district in which to demonstrate the value of the practical improvements discovered during the course of the work. This, however, does not solve the difficulty; it merely postpones it. The man in the street is not impressed by small areas and, sooner or later, the improvement must be extended beyond the enclave. Further, this arrangement does not solve the problem of duplication of effort.

The solution of the problem becomes much easier if the artificial division of the subject, into long-range and local problems, is given up and the more natural one, of research and demonstration, is adopted in its place. Each region should have a research institute of its own, which should be free to conduct investigations in whichever direction or manner appears to be the most profitable. As the number of such research institutes will be limited, they could be well equipped and could afford to employ only the best talent. Any practical results obtained could be made available to the general public by means of demonstration farms (of which there should be one in each district), and a specially selected staff working among the people. Such demonstration farms would require no scientific equipment and would be almost self-supporting. It should be clearly understood that no research work is attempted by the district staff. The art of demonstration and of inducing cultivators to adopt improvements is as important as that of research and every endeavour should be made to develop this branch of the subject as a separate and as an honoured profession.

The idea that, to be successful, every officer, working in the districts, must attempt something in the way of research must be given up entirely. Two branches—research and demonstration—which are both equally important should be developed in every agricultural department. The staff in each branch should be carefully selected for the work they have to perform. If any Central Government in the future wishes to encourage the development of the country, it can give grants-in-aid to the local research institutes. The division of the subject of agricultural improvement into its natural sub-divisions—research and demonstration—will prevent all friction and all overlapping.

The relation between the Institute of Plant Industry at Indore and its contributors has been arranged in accordance with this conception. All the research work is carried out at the Institute, where ample facilities for scientific investigations and a good library have been provided. The demonstration work is carried out by the Contributing States themselves, and it is hoped that in time each State will have a demonstration farm which will serve as a centre for local propaganda. Liaison is maintained by the methods outlined in Chapter VI, namely, by the visits of the Director to the States, of State officials and agricultural workers to the Institute, by cultivators' meetings and so forth. Up to the present, no difficulties have arisen and the experience obtained at Indore lends considerable support to the view that only one type of experiment station is needed.

The ideal system of conducting agricultural research in the Empire seems to lie in the simplification rather than in the elaboration of the organization. All that is necessary appears to be to provide each region with a research institute of its own, to do everything possible to increase the efficiency of these centres and to allow the workers every facility for un-official consultation and discussion, such as is provided by the meetings of the British Association, the Indian Science Congress and similar bodies. Better men are needed, not more machinery. Any funds that can be provided in the future for agricultural research should be devoted to the payment of competent investigators and to the provision of the means necessary for these men to work out their ideas. In other words, agricultural research must be made a profession. Until this is done, no real progress is possible. Any attempt to overstrain systems of organization in the hope that they may replace competent investigators can only end in failure. In research, the man is everything; the organization is a minor matter.

APPENDICES

A. LIST OF PAPERS ILLUSTRATING THE SCOPE OF CROP-PRODUCTION

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60. The Improvement of Crops. Vol. VIII, 1913, p. 111.

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B. MEMORANDUM OF ASSOCIATION AND RULES OF THE INSTITUTE OF PLANT INDUSTRY, INDORE

I. Memorandum of Association

1. The name of the Society is "The Institute of Plant Industry, Indore".

2. The objects for which the Society is established are :—

(*a*) The investigation of all matters relating to the production and improvement of raw cotton in India.

(*b*) The agricultural development of the territories of the Princes and Chiefs under the Suzerainty of His Majesty exercised through the Governor-General of India or through any Governor or other officer subordinate to the Governor-General of India who shall be members of the Society.

(*c*) The training of officers and cultivators nominated by such Princes and Chiefs.

(*d*) The training of advanced students nominated by the Indian Central Cotton Committee.

(*e*) To acquire either by purchase, exchange, lease, gift or otherwise, and to hold, sell, receive the purchase money of, convey, assign, lease, exchange and administer property, both movable and immovable, in any part of India and to administer and utilize all such property wholly and completely in furtherance of the aims and ends of the Society and of the Indian Central Cotton Committee only and not for the achievement of any other object whatsoever.

(*f*) To lay out and prepare for building purposes any lands acquired by or leased to the Society.

(*g*) To erect or procure the erection of buildings of any and all kinds, upon any such lands as aforesaid and to alter, pull down, improve, decorate, maintain, furnish and do any other works on or for or in respect to, all or any buildings in which the Society may be interested.

(*h*) To aid in the establishment and support of Associations for the benefit of persons employed by the Society or in any way connected with cotton growing and marketing in India and in particular, but without limiting the sense of the foregoing, of Friendly Societies for the benefit of any of such persons.

(*i*) To receive money on deposit at interest or otherwise.

(*j*) To invest or lend money whether belonging or intrusted to the

Society upon such securities and in such manner as may from time to time be determined by the Society.

(*k*) To raise money on mortgage or charge or in such other manner as the Society shall think fit and in particular by the issue of debentures charged upon all or any of the property of the Society both present and future.

(*l*) To do all or any of the above things either alone or in conjunction with others and to do all other such things as the Society may consider necessary incidental or conductive to the attainment of the above objects.

3. The Governing Body of the Society shall be the Board of Governors of the Society constituted to be the Governing Body under the Rules and Regulations of the Society and the first members of the said Board of Governors shall be the following :—

Names	Addresses	Occupations
1. The Hon'ble Sir Reginald Glancy, K.C.I.E., C.S.I., I.C.S.	The Residency, Indore.	Agent to the Governor General in Central India.
2. Sir Purshotamdas Thakurdas, Kt., C.I.E., M.L.A.	Malabar Castle, Ridge Road, Bombay.	Merchant.
3. Dr. D. Clouston, C.I.E.	Pusa, Bihar.	Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa.
4. Mr. J. H. Ritchie.	25, Wodehouse Road, Bombay.	Secretary, Indian Central Cotton Committee.
5. Mr. C. R. Palairet, M.I.E.E.	Indore, Central India.	Member for Commerce and Industry, Holkar State.
6. Mr. C. K. Chhaya, L. Ag.	Dhar, Central India.	Agricultural Superintendent, Dhar.
7. Nasrat Mahomed Khan, M.A., LL.B.	Jaora, Central India.	Superintendent, Chief Secretary's Office, Jaora.

4. The income and property of the Society whencesoever derived shall be applied towards the promotion of the objects thereof as set forth in this Memorandum of Association and no portion thereof shall be paid or transferred, directly or indirectly by way of dividends, bonus, or otherwise howsoever by way of profit to the persons who at any time are or have been members of the Society or to any of them or to any persons claiming

through them or any of them provided that nothing herein contained shall prevent the payment in good faith of remuneration, to any officers or servants of the Society or to any member thereof or other persons in return for any service actually rendered to the Society.

5. If on the winding up or dissolution of the Society there shall remain after the satisfaction of all its debts and liabilities any property whatsoever the same shall not be paid to, or distributed among the members of the Society or any of them but shall be given or transferred to some other Association, Institution or Society having objects similar to the objects of the Society to be determined by the Society or before the time of dissolution and in default thereof by the Indore State.

The Government of India being interested in the Society by virtue of the provisions of Section 14 of the Indian Cotton Cess Act the Society shall not be dissolved without the consent of the Governor-General-in-Council.

We the several persons whose names are subscribed are desirous of being formed into an Association in pursuance of this Memorandum of Association.

Name	Addresses	Description of Subscribers
1. R. I. R. Glancy	The Residency, Indore.	Agent to the Governor-General in Central India.
2. Purshotamdas Thakurdas	Malabar Castle, Ridge Road, Bombay.	Merchant.
3. D. Clouston	Pusa, Bihar.	Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa.
4. J. H. Ritchie	25, Woodhouse Road, Bombay.	Secretary, Indian Central Cotton Committee.
5. C. R. Palairet	Indore, Central India.	Member for Commerce and Industry, Holkar State.
6. C. K. Chhaya	Dhar, Central India.	Agricultural Superintendent, Dhar.
7. Nasrat Mahomed Khan	Jaora, Central India.	Superintendent, Chief Secretary's Office, Jaora.

Dated the twenty-fifth day of July, 1928.

II. Rules and Regulations

1. In these Rules and Regulations the following words shall have the following meaning :

"The Society" shall mean the Institute of Plant Industry.

"The Board of Governors" shall mean the Board of Governors which is under Rule and Regulation No. 5 and the Rules and Regulations following that Rule and Regulation the Governing Body of the Society.

"The President" shall mean the President of the Board of Governors as herein defined.

"The Secretary" shall mean the Secretary appointed under Rule and Regulation.

"The Indian Central Cotton Committee" shall mean the Indian Central Cotton Committee constituted under the Indian Cotton Cess Act XIV of 1923.

"The Territories" shall mean the Territories of any Indian Prince or Chief under the Suzerainty of His Majesty exercised through the Governor-General of India or through any Governor or other officer subordinate to the Governor-General.

Members of the Society

2. The members for the time being of the Society shall be the representatives of the Indian Central Cotton Committee, the representatives of the Territories which have at the date of the registration of the Society agreed to contribute to the Society and the representatives of the Territories which may from time to time agree to subscribe to the funds of the Society and which the Board of Governors may in their discretion accept as members of the Society and the Agent to the Governor-General in Central India.

3. The Society shall keep a roll of members and every member of the said Society shall sign the roll and shall state therein his rank or occupation and address.

4. If a member of the Society shall change his address he may notify his new address to the Secretary who shall thereupon enter his new address in the roll of members ; but if he shall fail to notify his new address the address in the roll of members shall be deemed to be his address.

Governing Body

5. The Governing Body shall be the Board of Governors and shall consist of a President and six members.

6. Three members of the Board of Governors shall be appointed by the Indian Central Cotton Committee, one member by the Holkar State and two members by such two of the Territories other than the Holkar State as shall have the right of appointment in the year in which such appointment falls to be made.

For the purpose of this Rule two of the Territories other than the

Holkar State shall appoint in rotation. The order of rotation shall be as follows :—Datia, Dhar, Dewas S. B., Jaora, Ratlam, Sitamau, Narsinghgarh, Tonk, Bijawar, Barwani, Jhalawar, and Bikaner.

As and when any new Territory agrees to subscribe to the Society and a representative of such Territory has been elected a member such Territory shall be placed after the last Territory in the order of rotation obtaining on the date on which the representative of such new Territory becomes a member and such Territory shall have the same right of appointing in rotation as the Territories abovementioned on the footing that such new Territory is then and thenceforward one of the Territories other than the Holkar State for the purpose of these Rules.

7. The Members of the Board of Governors appointed by the Indian Central Cotton Committee and by the Holkar State shall hold office for 3 years.

8. The two members of the Board of Governors appointed by such two of the Territories other than the Holkar State as shall have the right of appointing in the year in which the appointment falls to be made shall hold office for one year.

9. Any casual vacancy occurring in the number of the Board of Governors shall be filled up by appointment by the party who shall have nominated the member so dying or retiring.

10. The Agent to the Governor-General in Central India for the time being shall be *ex-officio* a member of the Board of Governors and shall also be *ex-officio* President of the Board.

11. The Board of Governors may elect a Vice-Chairman.

PROCEEDINGS OF THE BOARD OF GOVERNORS

12. The President of the Board of Governors shall preside at all the meetings of the Board.

13. If the President shall not be present at any meeting of the Board the Vice-President shall preside at such meeting.

14. If neither the President nor the Vice-President shall be present at any meeting of the Board the Board shall elect a Chairman to preside at such meeting.

15. Four members of the Board present in person shall constitute a quorum at any meeting of the Board.

16. Four clear days' notice of every meeting of the Board shall be sent to each member of the Board who shall for the time being be in India.

17. One meeting at least of the Board shall be held between 1st April and 31st March in every year.

18. The President of the Board may himself call, or by a requisition in writing signed by him may require the Secretary to call, a meeting of the Board at any time.

19. In case of a difference of opinion amongst the members of the Board the opinion of the majority shall prevail.

20. If there shall be an equality of votes on any question to be decided by the Board the Chairman shall have a casting vote.

POWERS OF THE BOARD OF GOVERNORS

21. The Board of Governors shall have the management of all the affairs and funds and shall have authority to exercise all the powers of the Society.

OFFICERS

22. The Officers of the Society shall be a President and Secretary and Treasurer. The Agent to the Governor General in Central India shall be the President of the Society. The Director for the time being of the Institute shall be the Secretary and Treasurer and the First Secretary shall be Mr. Albert Howard, C.I.E., M.A., Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India and Rajputana.

23. The Secretary shall keep a record of the proceedings of the Society and of the Governing Body and shall perform all such duties as usually pertain to the office of Secretary.

PROPERTY OF THE SOCIETY

24. The property of the Society both movable and immovable shall be vested in the Board of Governors.

25. The Funds of the Society shall be paid as received into the Imperial Bank of India, Indore. The Secretary shall have power to draw any cheque up to and including Rs. 3,000 (Rupees three thousand only) on his own signature. Cheques over Rs. 3,000 shall be counter-signed by the President or in his absence from Indore by the Secretary to the Agent to the Governor General in Central India.

26. The Secretary shall exercise such financial powers as may be delegated to him from time to time by resolution of the Board of Governors.

BUDGET

27. A budget shall be prepared for each year between April 1st to March 31st and shall be submitted to the Board of Governors for sanction. Re-appropriation between major heads of expenditure shall require the sanction of the Board of Governors but may be submitted to them by circular and may, in case of emergency, be sanctioned by the President and reported to the Board.

ACCOUNTS AND AUDIT

28. (*a*) The Director of the Institute shall maintain the accounts of all receipts and expenditure.

(*b*) Such accounts shall be audited quarterly in January, April, July,

or October by a firm of Chartered or Public Accountants appointed annually by the Board of Governors.

(*c*) A statement of receipts and expenditure relating to each financial year together with the Auditors' report thereon shall be submitted to the Board of Governors and to all members.

(*d*) The Auditors shall be appointed annually by the Board of Governors.

APPOINTMENT OF OFFICERS AND SERVANTS

29. (*a*) The power to create appointments to be paid from the funds of the Institute shall be vested in the Board of Governors *Provided* that, subject to the existence of budget provision, the Secretary may create temporary posts for a period not exceeding one year and on a salary not exceeding Rs. 50 per mensem in each instance. The Secretary shall have power to regulate the number of monthly paid men on wages not exceeding Rs. 50 per mensem to be employed from time to time for cultivation and for the general work of the Institute and paid from the budget allotment for farm expenses.

(*b*) No appointment to a post with a maximum salary of Rs. 250 per mensem or more shall be made without the consent of the Board of Governors. Nominations shall be made by a Selection Committee consisting of the President of the Board of Governors, the President or Secretary of the Indian Central Cotton Committee, the representative of the Holkar State and the Director of the Institute. Such nominations shall be submitted (by circular) to the Board of Governors for their approval. For the purpose of this rule two shall form a quorum.

(*c*) Appointments to posts of which the maximum pay is below Rs. 250 per mensem shall be made by the Secretary. The Secretary is authorized, in the case of any appointments made by him, to fill vacancies on less than the sanctioned scale of pay whenever this is desirable.

(*d*) The authority competent to dismiss, promote or degrade any officer or servant of the Institute shall be the authority empowered to appoint such officer or servant.

(*e*) The Director may, with the sanction of the President, suspend any officer or servant of the Institute (including any in receipt of more than Rs. 250 per mensem) pending the orders of the Board of Governors.

LEAVE, PENSION, PROVIDENT FUND, AND ALLOWANCES

30. (*a*) In the case of permanent Government servants whose services have been lent to the Institute, leave and pension contributions will be paid from the funds of the Institute. The Government Rules in force as regards leave and travelling allowance shall be followed in such cases. In the case of servants lent by the Indian States, leave and pension contributions will be paid from the funds of the Institute in accordance with the rules of the Indian States concerned subject to the proviso that such payments shall not exceed those laid down by Government.

(*b*) The travelling allowance of all officers and servants who are not in Government employ shall be governed by the rules in force in the Central India Agency.

(*c*) No pension will be paid to any officer or servant from the funds of the Institute. In place of pensions a Provident Fund has been constituted.

(*d*) The leave of the staff of the Institute will follow the rules in force in the Central India Agency.

(*e*) The Board of Governors shall sanction a list of holidays on which the Institute will be closed except for work of extreme urgency.

ANNUAL REPORT

31. The Director shall furnish an Annual Report to the Board of Governors, which shall be published in due course with the approval of the Governing Body, and sent to all the members.

SUITS BY AND AGAINST THE INSTITUTE

32. The Institute will sue or be sued in the name of the Secretary.

33. The Board of Governors may make bye-laws consistent with these rules for the regulation of the work of the Institute and for the management of its affairs.

OFFICE OF THE SOCIETY

34. The Office of the Society shall, unless otherwise determined by the Governing Body, be situated at Indore.

NOTICES

35. A notice may be served upon any member of the Society either personally or by sending it through the post in an envelope addressed to such member at his registered place of abode.

36. Any notice so served by post shall be deemed to have been served at the time when the cover containing the same would be delivered in the ordinary course of the post and in proving such service it shall be sufficient to prove that the cover containing such notice was properly addressed and put into the post office.

ALTERATION, EXTENSION, OR ABRIDGEMENT OF THE PURPOSES OF THE SOCIETY OR AMALGAMATION WITH ANY OTHER SOCIETY

37. *Provided that the previous consent of the Governor-General-in-Council is obtained,* the Society may alter, extend or abridge the purposes for which it is established, and may amalgamate either wholly or in part with any other Society—

(*a*) If the Governing Body shall submit the proposition for such alteration, extension, or abridgement as aforesaid, or for such

amalgamation as aforesaid as the case may be, to the members of the Society in a written or printed report, and

(*b*) If the Governing Body shall convene a special general meeting of the members of the Society according to their Rules and Regulations, for the consideration of the said proposition, and

(*c*) If such report be delivered or sent by post to every member of the Society ten days previous to such Special General Meeting as aforesaid.

(*d*) If such proposition be agreed to by the votes of three-fifths of the members of the Society delivered in person at such Special General Meeting as aforesaid, and

(*e*) If such proposition be confirmed by the votes of three-fifths of the members of the Society present at a second Special General *Meeting, convened by the Governing Body at an interval of one* month after the former meeting.

Alterations of Rules and Regulations

38. The Rules and Regulations of the Society, save and except the Rule and Regulation No. 37, may be altered at any time by a Resolution passed by a majority of the members of the Society present at any meeting of the Society, which shall have been duly convened for the purpose.

C. LIST OF PERIODICALS TAKEN IN THE LIBRARY

Agricultural Journal of India
Agricultural Progress
American Journal of Botany
Angewandte Botanik
Annals of Applied Biology
Annals of Botany
Bibliographia Genetica
Biedermann's Centralblatt
Botanical Abstracts (now continued as Biological Abstracts)
Bombay Co-operative Quarterly
Botanical Gazette
Botanical Magazine
Botanisches Centralblatt
British Cotton Industry Research Association.—Summary of Current Literature
British Journal of Experimental Biology
Bulletins of the Agricultural Research Institute, Pusa
Bulletin of Applied Botany and Plant Breeding
Bulletin de l'Association Internationale des Sélectionneurs de Plantes de Grande Culture
Capital
Chemical Abstracts (American)
Chemical Abstracts "A" (British)
Discovery
Ecology
Empire Cotton Growing Review
Experiment Station Record
Genetica
Genetics
Hereditas
Indian Journal of Economics
Indian Trade Journal
Industrial and Engineering Chemistry
Industrial and Engineering Chemistry (News Edition)
International Cotton Bulletin
International Review of the Science and Practice of Agriculture (continued as International Review of Agriculture)
International Sugar Journal
Jahrbücher für wissenschaftliche Botanik

Journal of Agricultural Research
Journal of Agricultural Science
Journal of the Central Bureau for Animal Husbandry and Dairying
Journal of the Bombay Natural History Society
Journal of the Chemical Society of London
Journal of Ecology
Journal of Genetics
Journal of the Royal Society of Arts
Journal of the Textile Institute
Journal of the American Society of Agronomy
Journal and Proceedings of the Asiatic Society of Bengal
Journal of the Linnean Society
Journal of the Royal Horticultural Society
Kisan (Hindi)
Landwirtschaftliche Jahrbücher
Landwirtschaftlichen Versuchs-Stationen
Memoirs of the Department of Agriculture in India:—Bacteriological Series, Botanical Series, Chemical Series, Entomological Series, and Veterinary Series
Nature
New Phytologist
Philosophical Transactions of the Royal Society of London, Series "B"
Physiological Abstracts
Plant Physiology
Proceedings of the Chemical Society
Proceedings of the Royal Society, Series "B"
Protoplasma
Quarterly Review of Biology
Record
Report of the British Association for the Advancement of Science
Resumptio Genetica
Revue Technique du Monopole des Tabacs
Science Progress
Shirley Institute Memoirs
Soil Science
Tropenpflanzer
Tropical Agriculture
Tropical Agriculturist
Tropical Life
Transactions of the Daghistan Agricultural Plant Breeding Station
Zeitschrift für induktive Abstammungs- und Vererbungslehre
Zeitschrift für Pflanzenzüchtung
Zell-stimulations-forschungen

D. LIST OF BENEFACTIONS

		Rs.	A.	P.
1.	Balance from the old fund (contributed by the following States—Datia, Rs. 1,046-10-0; Dhar, Rs. 1,395-8-0; Dewas, S.B., Rs. 697-12-6; Jaora, Rs. 1,395-8-0; Ratlam, Rs. 1,046-10-0 and Sitamau, Rs. 348-14-3). The Darbars agreed to devote these balances—Rs. 5,930-14-9 in all—to the formation of a Library for the Institute ..	5,930	14	9
2.	Special donation by the Indian Central Cotton Committee for Roads and Quarters	33,333	0	0
3.	Additional donation by the Indian Central Cotton Committee for 1928-29 and 1929-30	45,000	0	0
4.	Donation for Vernacular Publications from Shri Raja Govind Singhji of Jaipur	100	0	0
5.	Donation for the Lending Library from Shri Raja Govind Singhji of Jaipur	100	0	0
6.	Donation for the Lending Library from Khan Sahib B. K. Illava, Mhow	200	0	0
7.	Donation for the Lending Library from Mr. R. S. Patel, Mhow	200	0	0
8.	Donation from the Holkar State for the erection and furnishing of the Holkar State Visitors' Quarters	9,298	0	0
9.	Addition to the annual contribution of the Holkar State for the year ended 30th September, 1928 ..	5,000	0	0
10.	Donation from the Government of H.E.H. the Nizam of Hyderabad	500	0	0
11.	Irwin Studentship for the Agronomy of Cotton, founded by Rai Bahadur Sir Sarupchandji Hukamchand, Kt., Indore	4,000	0	0
12.	Nineteen volumes of the *Journal of the Royal Society of Arts* (from an anonymous donor)			
13.	Donation for Hindi Publications from Dewan Bahadur Sirdar Pandit Narayan Prasad of Dewas (S.B.)	100	0	0
	Total Rs. ..	103,761	14	9

E. PROGRAMME OF INVESTIGATIONS ON COTTON

BOTANICAL SURVEY

Up to the present, little or no attempt has been made in India to isolate, classify and study the unit species which form the framework of the various species and varieties of cotton found on the black soils. It is true that the Indian cottons have been classified and surveyed from the point of view of systematic botany, but this is entirely inadequate for modern work as by this method cottons of very different agricultural value are not distinguished. This work has a direct practical bearing. It will, in all probability, lead to the isolation of useful types for distribution. It will also provide material for the plant-breeder and for critical work on the physiology and agronomy of cotton.

PLANT BREEDING

Two main practical problems will be taken up at once—(1) the creation, establishment and maintenance of an island of improved cotton on the Malwa plateau. The types isolated will be available for other areas in India and the crop will enable a grade of improved cotton to be established for the mills and for the shippers; (2) the improvement of the fibre of the hardy *roseum* type which is, in all other respects, admirably suited for the low-lying areas of Central India. In the solution of these questions, the inheritance of characters will have to be studied. The results will apply not only locally but will also be of general interest.

THE PHYSIOLOGY OF THE COTTON CROP

In order to increase production something more than improved varieties is needed. The new varieties must be provided with suitable conditions for growth. To discover these, the physiology of the cotton plant must be studied and the factors which now limit production must be determined. This involves the study of root-development, the relations of the root-system to the soil type and the influence of factors, such as soil moisture, soil-aeration and drainage, soil texture and soil temperature, on growth. Included in these studies is the discovery of the factors which produce the shedding of buds, flowers and bolls. During the course of these physiological studies, the general nutrition of the cotton plant will be considered and how far the yield can be improved by manuring and other methods of soil treatment.

THE INFLUENCE OF ENVIRONMENTAL FACTORS ON THE LINT CHARACTERS

Modern industries demand a uniform product. Once this is obtained, the purchase of raw material as well as the details of manufacture are

simplified. In the case of cotton, any tract which can produce uniform lint will rapidly establish its reputation in the trade. It is well known, however, that the cotton fibre alters in character according to the soil on which it grows and to some extent according to the season. Further work is desirable on this matter with the object of discovering what factors bring about these changes, which varieties are most easily affected and whether any practical remedies exist for improving the uniformity of the fibre of the same cotton. This portion of the work is of direct bearing on the question of the maintenance of grades of cotton for the highest class of spinning in this country.